Cell 1 Regional Coastal Monitoring Programme
Analytical Report 9 Full Measures Survey 2016

Scarborough Council
March 2017

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Authors	
Emma Hick	Royal HaskoningDHV
Dr Nick Cooper – Review of Draft	Royal HaskoningDHV
Dr Nick Cooper – Approval of Final	Royal HaskoningDHV

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Abbreviations and Acronyms

Acronym / Abbreviation	Definition
AONB	Area of Outstanding Natural Beauty
DGM	Digital Ground Model
HAT	Highest Astronomical Tide
LAT	Lowest Astronomical Tide
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWS	Mean Low Water Neap
MLWS	Mean Low Water Spring
m	metres
ODN	Ordnance Datum Newlyn

Water Levels Used in Interpretation of Changes

Water Level Parameter	Water Level (m AOD) Hartlepool Headland to Saltburn Scar	Skinningrove	Hummersea Scar to Sandsend Ness	Sandsend Ness to Saltwick Nab
1 in 200 year	3.87	3.86	4.1	3.88
HAT	3.25	3.18	3.15	3.10
MHWS	2.65	2.68	2.65	2.60
MLWS	-1.95	-2.13	-2.15	-2.20
Water Level Parameter	**Water Level (m AOD) Saltwick Nab to Hundale Point**	**Hundale Point to White Nab**	**White Nab to Filey Brigg**	**Filey Brigg to Flamborough Head**
1 in 200 year	3.88	3.93	3.93	4.04
HAT	3.10	3.05	3.05	3.10
MHWS	2.60	2.45	2.45	2.50
MLWS	-2.20	-2.35	-2.35	-2.30

Source: *River Tyne to Flamborough Head Shoreline Management Plan 2*. Royal Haskoning, February 2007.

Glossary of Terms

Term	Definition
Beach nourishment	Artificial process of replenishing a beach with material from another source.
Berm crest	Ridge of sand or gravel deposited by wave action on the shore just above the normal high water mark.
Breaker zone	Area in the sea where the waves break.
Coastal squeeze	The reduction in habitat area which can arise if the natural landward migration of a habitat under sea level rise is prevented by the fixing of the high water mark, e.g. a sea wall.
Downdrift	Direction of alongshore movement of beach materials.
Ebb-tide	The falling tide, part of the tidal cycle between high water and the next low water.
Fetch	Length of water over which a given wind has blown that determines the size of the waves produced.
Flood-tide	Rising tide, part of the tidal cycle between low water and the next high water.
Foreshore	Zone between the high water and low water marks, also known as the intertidal zone.
Geomorphology	The branch of physical geography/geology which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
Groyne	Shore protection structure built perpendicular to the shore; designed to trap sediment.
Mean High Water (MHW)	The average of all high waters observed over a sufficiently long period.
Mean Low Water (MLW)	The average of all low waters observed over a sufficiently long period.
Mean Sea Level (MSL)	Average height of the sea surface over a 19-year period.
Offshore zone	Extends from the low water mark to a water depth of about 15 m and is permanently covered with water.
Storm surge	A rise in the sea surface on an open coast, resulting from a storm.
Swell	Waves that have travelled out of the area in which they were generated.
Tidal prism	The volume of water within the estuary between the level of high and low tide, typically taken for mean spring tides.
Tide	Periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating earth.
Topography	Configuration of a surface including its relief and the position of its natural and man-made features.
Transgression	The landward movement of the shoreline in response to a rise in relative sea level.
Updrift	Direction opposite to the predominant movement of longshore transport.
Wave direction	Direction from which a wave approaches.
Wave refraction	Process by which the direction of approach of a wave changes as it moves into shallow water.

Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the northeast England coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1). Within this frontage, the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial sediment to varying thicknesses, softer rock cliffs and extensive landslide complexes.

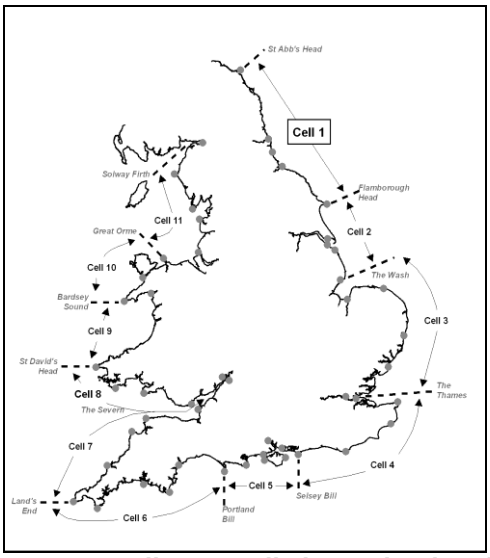


Figure 1 Sediment Cells in England and Wales

The work commenced with a three-year monitoring programme in September 2008 that was managed by Scarborough Borough Council on behalf of the North East Coastal Group. This initial phase has been followed by a five-year programme of work, which started in October 2011. The work is funded by the Environment Agency, working in partnership with the following organisations:

Northumberland County Council
North Tyneside Council
South Tyneside Council
Northumberland Coast AONB
Sunderland City Council
Durham County Council
Redcar & Cleveland Borough Council
Hartlepool Borough Council
Scarborough Borough Council — A great place to live, work & play
East Riding of Yorkshire Council
Environment Agency
Natural England
The National Trust

The main elements of the Cell 1 Regional Coastal Monitoring Programme involve:

- beach profile surveys
- topographic surveys
- cliff top recession surveys
- real-time wave data collection
- bathymetric and sea bed characterisation surveys
- aerial photography
- walk-over surveys

The beach profile surveys, topographic surveys and cliff top recession surveys are undertaken as a 'Full Measures' survey in autumn/early winter every year. Some of these surveys are then repeated the following spring as part of a Partial Measures survey.

Each year, an Analytical Report is produced for each individual authority, providing a detailed analysis and interpretation of the Full Measures surveys. This is followed by a brief Update Report for each individual authority, providing ongoing findings from the Partial Measures surveys. A Cell 1 Overview Report is also produced regularly to provide a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage.

To date the following reports have been produced:

Table 1 Analytical, Update and Overview Reports Produced to Date

Year		Full Measures		Partial Measures		Cell 1 Overview Report
		Survey	Analytical Report	Survey	Update Report	
1	2008/09	Sep-Dec 08	May 09	Mar-May 09		-
2	2009/10	Sep-Dec 09	Mar 10	Feb-Mar 10	July 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-April 11	August 11	Sept 11
4	2011/12	Sept 11	Aug 12	Mar-May 12	Feb 13	
5	2012/13	Sept 12	Mar 13	April-May 13	May 13	
6	2013/14	Sept 13	Feb 14	Mar-April 14	July 14	
7	2014/15	Sept 14	Feb 15	March 15	July 15	
8	2015/16	Sept 15	Feb 16	Mar – Apr 16	July 16	
9	2016/17	Sep–Nov16	Feb 17 (*)			

(*) The present report is **Analytical Report 9** and provides an analysis of the autumn/winter 2016 Full Measures survey for Scarborough Borough Council's frontage.

In addition, separate reports are produced for other elements of the programme as and when specific components are undertaken, such as wave data collection, bathymetric and sea bed sediment data collection, aerial photography, and walk-over visual inspections.

For purposes of analysis, the Cell 1 frontage has been split into the sub-sections listed in Table 2. Areas covered in the current report are highlighted

Table 2 Sub-divisions of the Cell 1 Coastline

Authority	Zone
Northumberland County Council	Spittal A
	Spittal B
	Goswick Sands
	Holy Island
	Bamburgh
	Beadnell Village
	Beadnell Bay
	Embelton Bay
	Boulmer
	Alnmouth Bay
	High Hauxley and Druridge Bay
	Lynemouth Bay
	Newbiggin Bay
	Cambois Bay
	Blyth South Beach
North Tyneside Council	Whitley Sands
	Cullercoats Bay
	Tynemouth Long Sands
	King Edward's Bay
South Tyneside Council	Littehaven Beach
	Herd Sands
	Trow Quarry (incl. Frenchman's Bay)
	Marsden Bay
Sunderland Council	Whitburn Bay
	Harbour and Docks
	Hendon to Ryhope (incl. Halliwell Banks)
Durham County Council	Featherbed Rocks
	Seaham
	Blast Beach
	Hawthorn Hive
	Blackhall Colliery
Hartlepool Borough Council	North Sands
	Headland
	Middleton
	Hartlepool Bay
Redcar & Cleveland Borough Council	Coatham Sands
	Redcar Sands
	Marske Sands
	Saltburn Sands
	Cattersty Sands (Skinningrove)
Scarborough Borough Council	Staithes
	Runswick Bay
	Sandsend Beach, Upgang Beach and Whitby Sands
	Robin Hood's Bay
	Scarborough North Bay
	Scarborough South Bay
	Cayton Bay
	Filey Bay

1. Introduction

1.1 Study Area

Scarborough Borough Council's frontage extends from Staithes Harbour to Speeton, in Filey Bay. For the purposes of this report, the Scarborough frontage has been sub-divided into eight areas, namely:

- Staithes
- Runswick Bay
- Sandsend Beach, Upgang Beach and Whitby Sands
- Robin Hood's Bay
- Scarborough North Bay
- Scarborough South Bay
- Cayton Bay
- Filey Bay

1.2 Methodology

Along Scarborough Borough Council's frontage, the following surveying is undertaken:

- Full Measures survey annually each autumn/early winter comprising:
    - Beach profile surveys along 20 transect lines
    - Topographic survey at Runswick Bay
    - Topographic survey along the Sandsend to Whitby frontage
    - Topographic survey at Robin Hood's Bay
    - Topographic survey at Scarborough North Bay
    - Topographic survey at Scarborough South Bay
    - Topographic survey at Cayton Bay
    - Topographic survey at Filey Bay

- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 20 transect lines
    - Topographic survey at Runswick Bay
    - Topographic survey at Robin Hood's Bay
    - Topographic survey at Filey Bay (Town coverage)

- Cliff top survey bi-annually at:
    - Staithes
    - Robin Hood's Bay (added Spring 2010)
    - Scarborough South Bay (added Spring 2010)
    - Cayton Bay
    - Filey

The location of these surveys is shown in Figure 2. Full Measures surveys were undertaken along this frontage between 19th September 2016 and 18th November 2016. The weather and sea state varied greatly in that time, for details of the survey, conditions refer to the Academy Geomatics survey reports for each location.

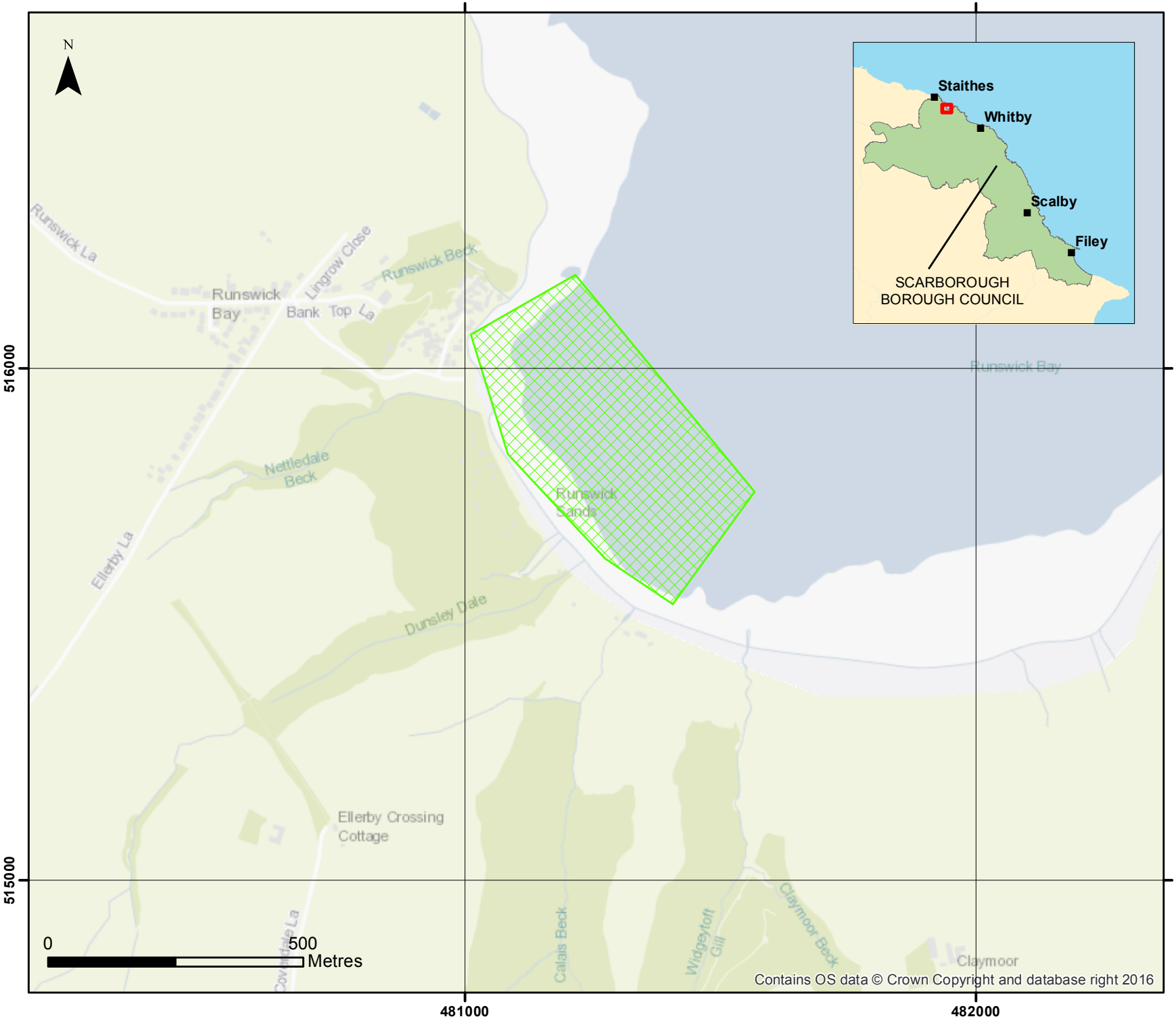
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data collection approach and file format is comparable to that being used on other regional coastal monitoring programmes, such as in the South East and South West of England.

Upon receipt of the data from the survey team, they are quality assured and then uploaded onto the programme's website for storage and availability to others and also input to SANDS and GIS for subsequent analysis.

The Analytical Report is then produced following a standard structure for each authority. This involves:

- description of the changes observed since the previous survey and an interpretation of the drivers of these changes (Section 2);
- documentation of any problems encountered during surveying or uncertainties inherent in the analysis (Section 3);
- recommendations for 'fine-tuning' the programme to enhance its outputs (Section 4); and
- providing key conclusions and highlighting any areas of concern (Section 5).

Data from the present survey are presented in a processed form in the Appendices.



Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 1

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:10,000

WATER
Royal HaskoningDHV
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

Tel: +44 (0)191 211 1300
Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

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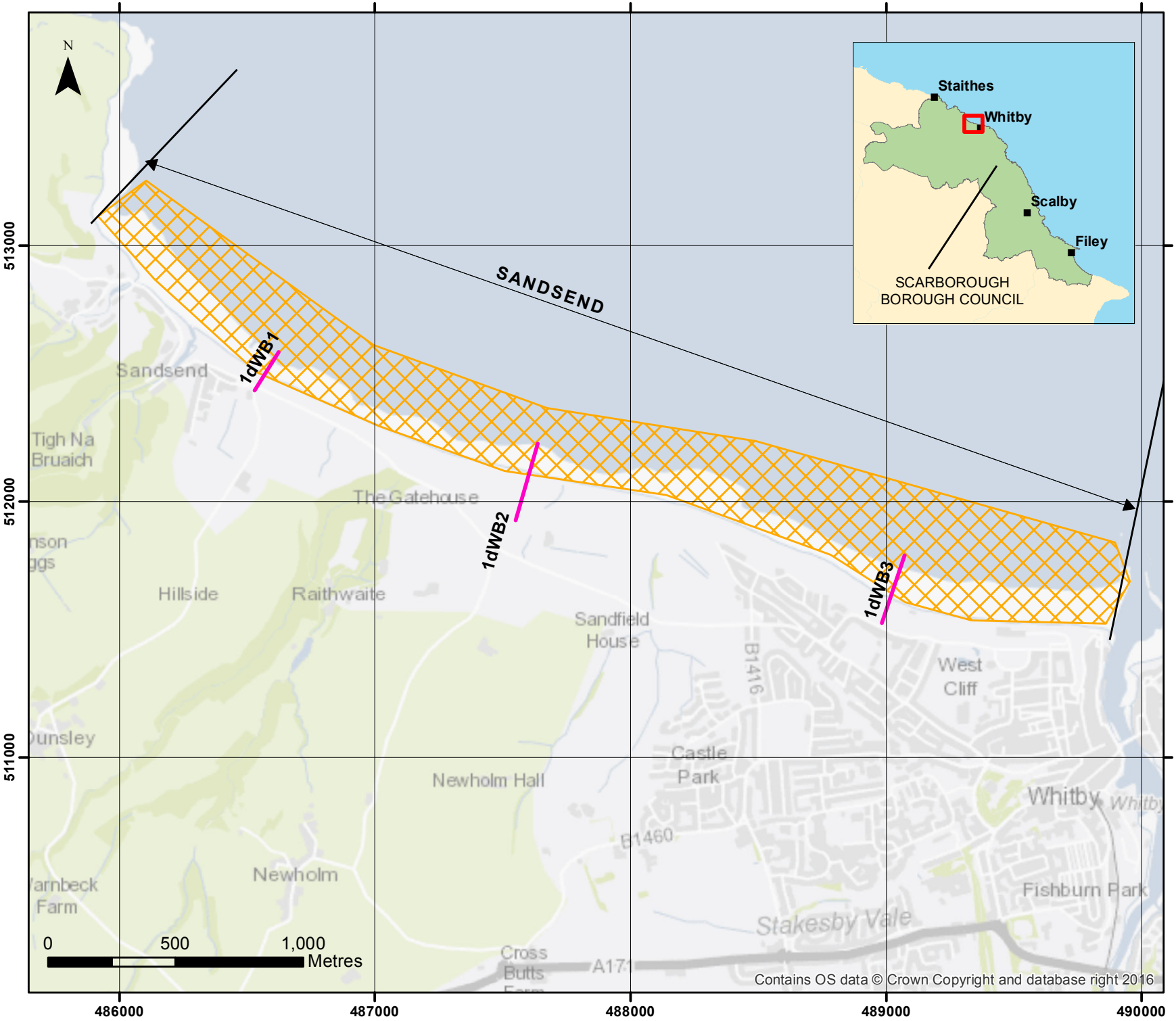

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 2

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:20,000

WATER
Royal HaskoningDHV
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

Tel: +44 (0)191 211 1300
Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

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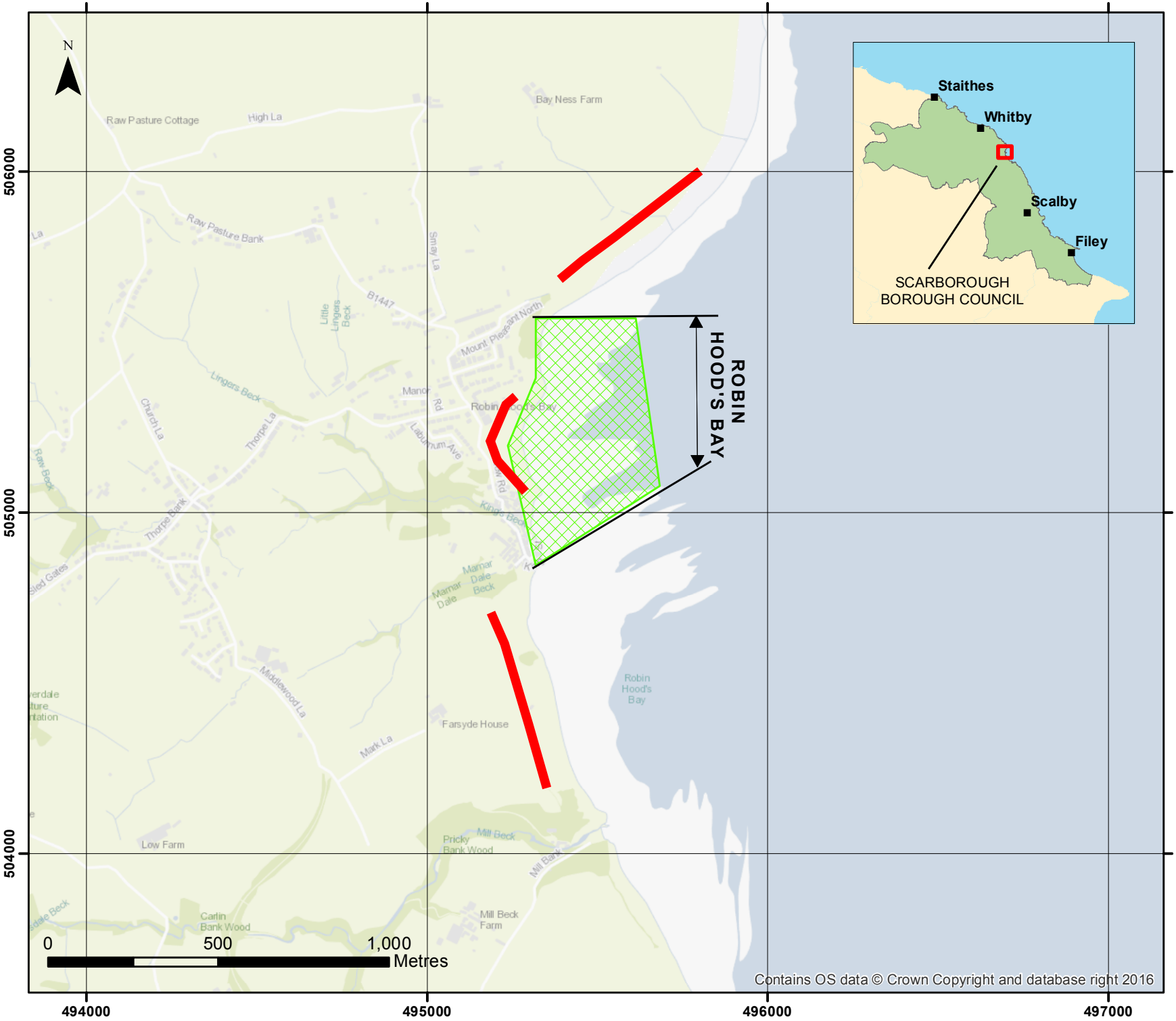

Key

SURVEY LOCATIONS

Topographic Profiles

Annual

Bi-Annual

Topographic Surveys

6 monthly

yearly

Cliff Top Monitoring Pegs

@ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 3

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

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Royal HaskoningDHV
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

Tel: +44 (0)191 211 1300
Fax: +44 (0)191 211 1313
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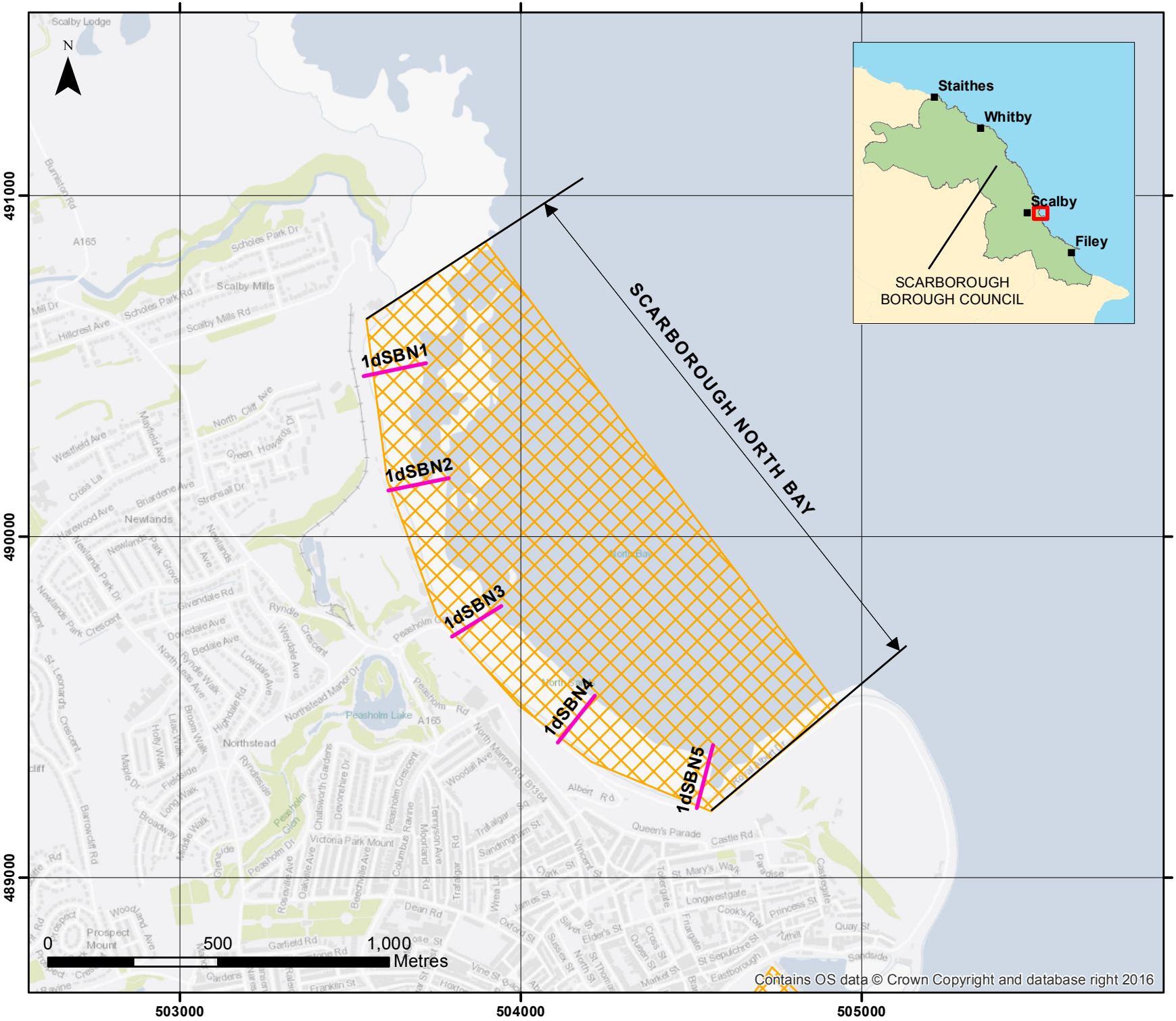

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 4

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

WATER
Royal HaskoningDHV
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

Tel: +44 (0)191 211 1300
Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

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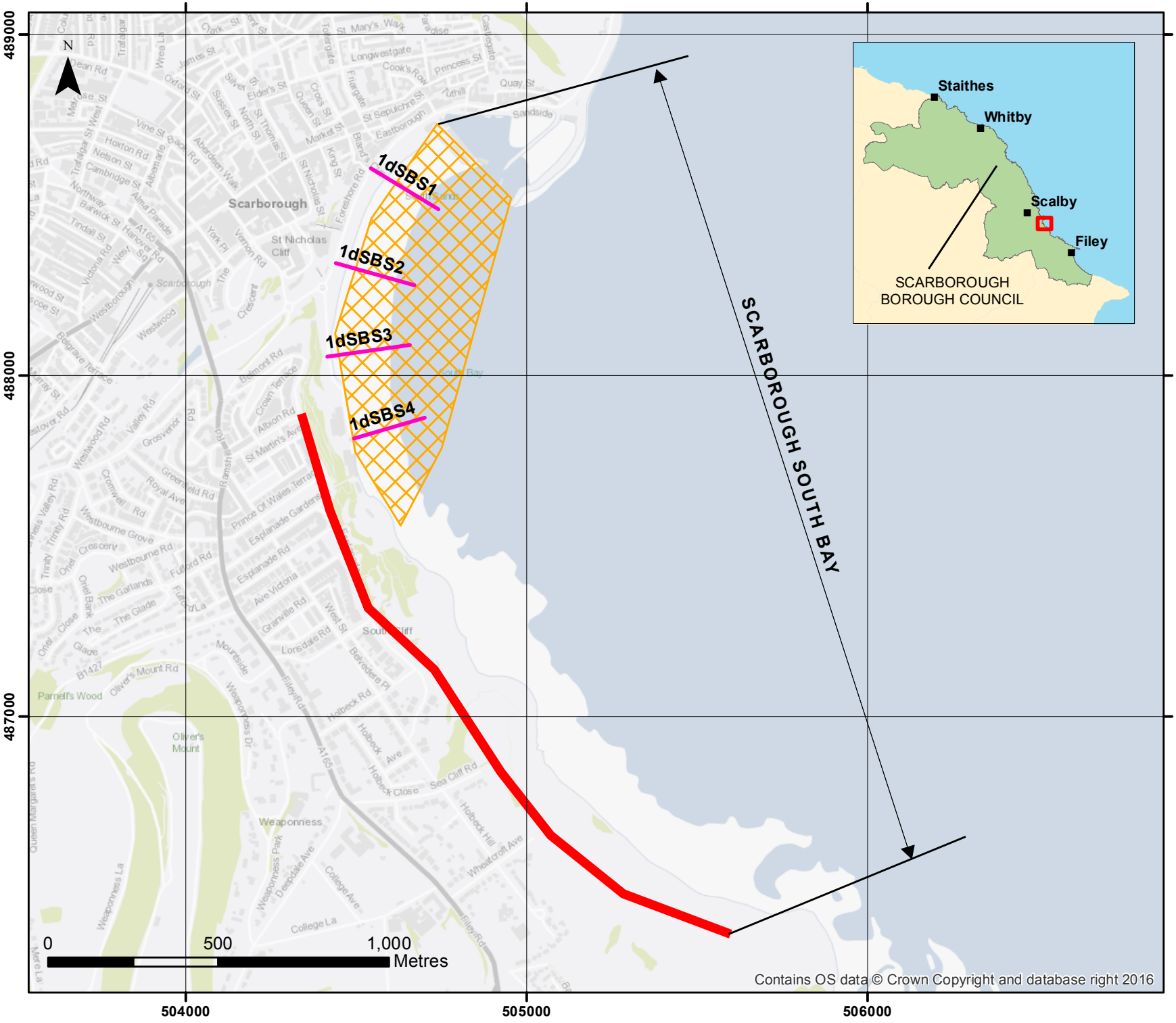

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly

Cliff Top Monitoring Pegs

- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 5

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

WATER
Royal HaskoningDHV
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

Tel: +44 (0)191 211 1300
Fax: +44 (0)191 211 1313
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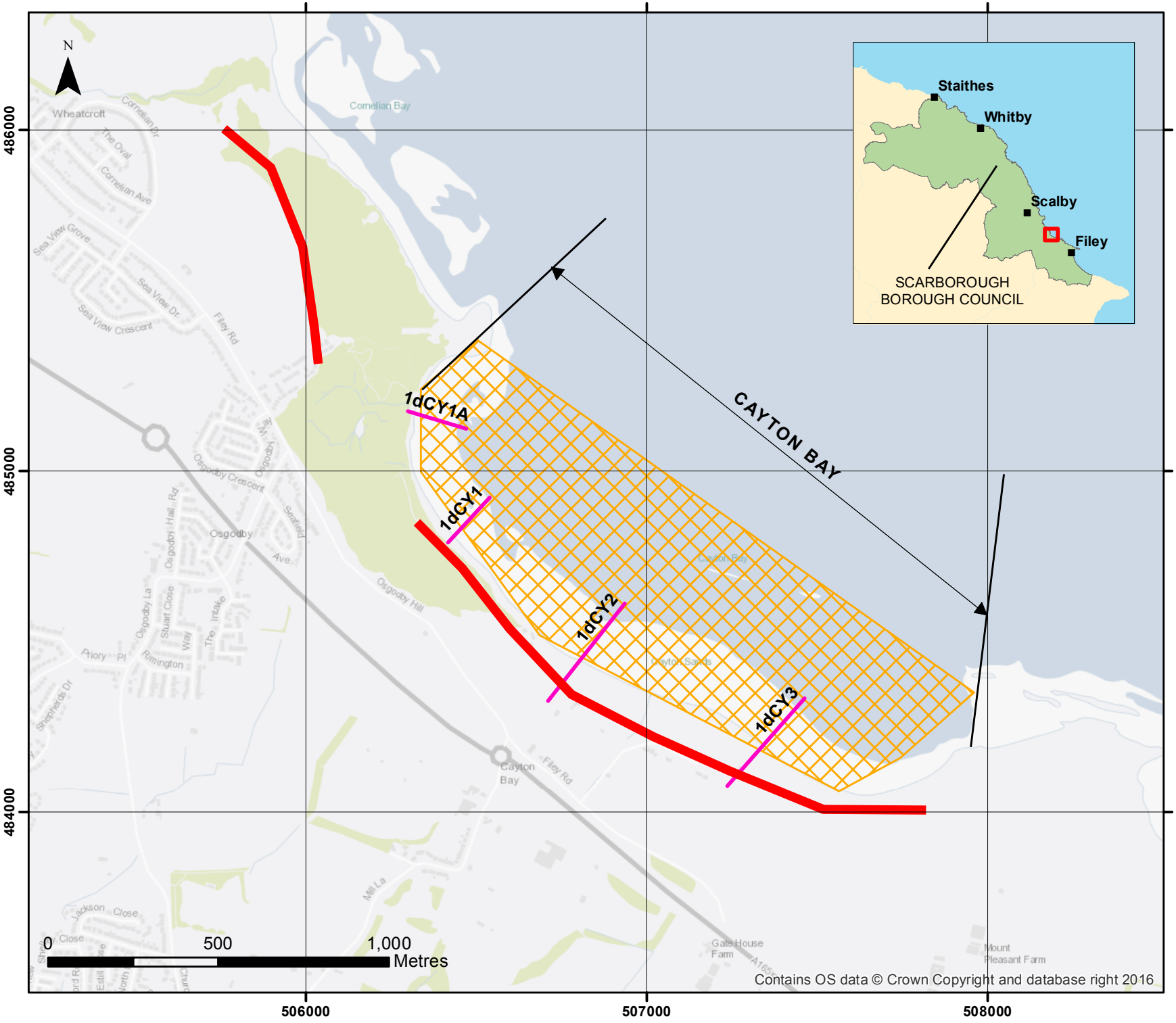

Key

SURVEY LOCATIONS

Cliff Top Monitoring Pegs

@ 300 centres

Topographic Profiles

Annual

Bi-Annual

Topographic Surveys

6 monthly

yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 6

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

WATER
Royal HaskoningDHV
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

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Fax: +44 (0)191 211 1313
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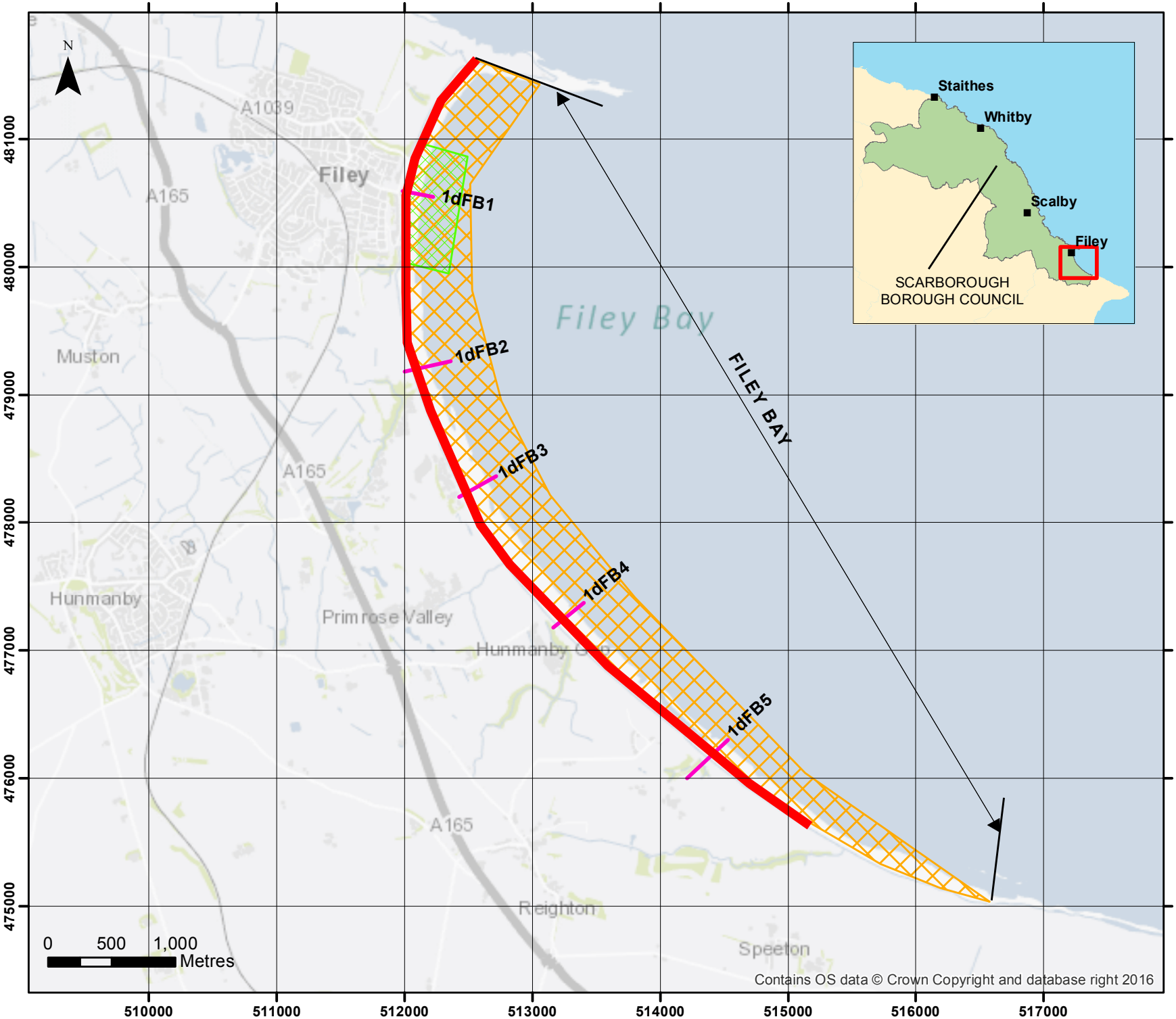

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly

Cliff Top Monitoring Pegs

- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 7

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:40,000

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Royal HaskoningDHV
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

Tel: +44 (0)191 211 1300
Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

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2. Analysis of Survey Data

2.1 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
23rd September 2016	**Cliff-top Survey:** Twenty ground control points have been established at Cowbar and Staithes for biannual cliff top monitoring. Locations 12 to 20 are in the Scarborough Borough Council area. The separation between any two points is around 100 m. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Between April 2016 and September 2016, nine of the 20 posts showed change within a range of ±0.1m, which is not considered significant given the error of the technique. Posts 3, 6, 7, and 13 showed the largest erosion with 0.1 to 0.3m cliff recession recorded. Calculation of longer-term erosion rates based on the recorded change between 2008 and 2015 indicates that eighteen on the frontage recorded a change rate within a range of ±0.1m/yr., which is considered to be within the error of the measurement. Post 13 (near the eastern breakwater) shows consistent erosion through the surveys at 0.3m/yr. Posts 9 to 12 were inaccessible due to a landslip on the headland; the area was fenced off by the National Trust. Appendix C provides results from the September 2016 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey.	Four stations showed erosion of between 0.1 and 0.3m over the summer of 2016. A further four stations were inaccessible due to a landslip on the headland suggesting there may have been significant recession in this area. **Longer term trends**: Table C1 shows that survey location 13 has shown the greatest total erosion with a loss of 2.3m (±0.3m) between the November 2008 baseline and September 2015, resulting in a long term average recession rate of 0.3m/yr. This area is above the eastern breakwater and is known to have experienced rock falls previously.

2.2 Runswick Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
19th September 2016	**Topographic Survey:** Runswick Bay is covered by a 6-monthly topographic survey. A consistently applied GIS processing routine has been used to create a digital ground model (DGM) (Appendix B - Map 1) and to calculate the differences between the current topographic survey (Autumn 2016) and the previous survey (Spring 2016) to highlight areas and amounts of erosion and deposition. In all cases, a 5m resolution raster grid has been used to identify areas of erosion and accretion. (Appendix B – Map 8). Appendix B - Map 1 shows shore parallel bands of change on the beach at Runswick Bay. Accretion dominates in the middle of the beach, whilst erosion is more prominent in the lower beach. In the centre of the bay (south of the rock armour), the upper beach has mainly undergone erosion. In the north west of the bay, directly in front of the village, there has been very little change in beach levels. The magnitude of change is generally quite small, less than ±0.75m.	Between March and September 2016 Runswick Bay showed a mixed pattern of erosion and accretion in two to three shore parallel bands, which show modest change of less than ±0.75m. This indicates movement of material from the top and bottom of the beach into the middle. **Longer term trends**: The changes in the bay have been no more than ±0.75m. the longer term pattern of erosion in front of the village has paused in 2016.

2.3 Sandsend Beach, Upgang Beach and Whitby Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
20th & 21st October 2016	**Beach Profiles:** The frontage spanning Sandsend Beach, Upgang Beach, and Whitby Sands is covered by three beach profile lines, spaced between Sandsend and Whitby West Cliff (Appendix A). The apparent retreat in the toe of the cliff at Profile **1dWB1** (located around 400m south of Sandsend Village) is due to the new defences; these were in the process of being constructed during the April 2016 survey and therefore this section of the profile was not surveyed. The beach level in front of the defences has increased by up to 0.5m across the whole profile compared to April 2016 beach levels, making it the highest recorded beach from chainage 80m. At **1dWB2** (located in centre of Upgang Beach), the profile to 140m chainage has not changed significantly. There has been a small amount of erosion of less than 0.2m at the toe of the cliff (chainage 145). Between chainage 150m and 185m there has been accretion of up to 0.5m. Between 185m and 215m there has been erosion of 0.2m, and seawards of 215m there has been significant accretion of up to 1m forming a lower beach berm. Overall the beach is low-medium in the upper and middle beach compared with the range recorded in previous surveys, but it is the highest on record for the lower beach. At profile **1dWB3** fronting the stabilised face of Whitby West Cliff, no change has occurred as far as 90m chainage. At the bottom of the seawall between 90m and 160m, chainage up to 0.6m has been gained since March 2016. Between 160m and 190m, chainage there has been very little change. Seawards of 190m chainage the beach has accreted by up to 0.4m. Overall, the two berms have formed on the upper and lower beach, this is similar behaviour to the October 2015 survey Overall the beach is high compared to the range recorded from previous surveys. **Topographic Survey:** The Sandsend to Whitby frontage is covered by an annual topographic survey, providing continuous data for Sandsend Beach, Upgang Beach, and Whitby Sands. Data have been used to create a DGM (Appendix B – Maps 2) using GIS.	The October 2016 profiles tended to be near the high-point of the range recorded by previous surveys, with accretion being the predominant process. . The topographic difference plots show a complex spatial pattern. There are more areas of accretion than erosion, and the magnitude tends to be similar, suggesting overall beach accretion. The erosion at the back of the beach suggests reworking of cliff fall debris. The cliffs of Upgang Beach in the central part of the study area are undefended and erosion provides an important source of material to the beach. It is likely that sediment released by erosion over the winter months is subsequently redistributed across the beach as migrating sand bars. **Longer term trends**: the beach profiles show seasonal variation but no linear trend of accretion or erosion. The annual topographic difference plots show similar patterns of accretion and erosion in the all surveys although the magnitude of change is modest.

Survey Date	Description of Changes Since Last Survey	Interpretation
	The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2016) and the earlier topographic survey DGM (Autumn 2015), with 5m resolution raster grids (as shown in Appendix B – Maps 9), to identify areas of erosion and accretion. Appendix B – Maps 9 show a varied picture of erosion and accretion. The greatest magnitude of change is in the west at Sandsend (±1.75m), decreasing to the east, with Whitby Sands showing little change (±0.5m). Generally, there is accretion in the middle beach and erosion in the upper beach, with a mixture of erosion and accretion in the lower beach.	

2.4 Robin Hood's Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
18th November 2016	**Topographic Survey:** Robin Hood's Bay is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B - Map 3) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2016) and the earlier topographic survey DGM (Spring 2016), with 5m resolution raster grids (as shown in Appendix B – Map 10), to identify areas of erosion and accretion. Appendix B - Map 10 shows a very patchy distribution of areas of accretion and erosion over the summer of 2016. The majority of the bay has seen little change (±0.25m) associated with the rocky outcrops which run perpendicular to the shore. The most coherent patch of erosion is in the centre of the bay at the toe of the slipway. This is opposite to the pattern observed in Spring 2016 and Autumn 2015. There was accretion at the toe of the undefended cliff at the centre of the bay. Overall, erosion is slightly more dominant and is up to 1m across the majority of the bay.	The topographic change plot shows that there has been very little change across the frontage over the summer of 2016. Cliff top monitoring shows little or no erosion since March 2016. **Longer term trends:** The limited change recorded in Robin Hoods Bay is due to the resistant rock platforms and thin, patchy cover of sand. The erosion of the cliff in the middle of the bay, which lead to the accretion of the beach, was not recorded by the cliff monitoring; suggesting failures of the cliff face did not result in cliff top recession.
	Cliff-top Survey: Thirteen ground control points have been established at Robin Hood's Bay since March 2010 to monitor cliff recession. The separation between any two points is around 200m. Table C2 shows that four locations showed erosion between March and November 2016, with markers 1, 2, 3, and 5 retreating by more than 0.1m. However, inspection of the survey photos indicates this is due to difficulty locating the cliff edge precisely as the break in slope is covered by vegetation. Using data recorded between March 2010 and November 2014, calculated erosion rates show little change in all markers except Marker 1, which shows recession of 0.6m/yr. However, this marker has showed very little change since March 2012.	

2.5 Scarborough North Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
18th October 2016 **And** **25th January 2017**	**Beach Profiles:** Scarborough North Bay is covered by five beach profile lines, distributed between the Sealife Centre at Scalby Mills and Clarence Gardens (Appendix A). These profiles were also surveyed on the 25th January 2017 as a response to the storm surge, in addition to the planned October 2016 Full Measures survey,. The October 2016 survey shows that Profile **1dSBN1** remains stable at the defended, upper part of the profile. From 10m to 30m chainage, minor accretion of 0.2m of material has occurred since March 2016. Between 30m to 90m chainage, the beach is very similar to the March 2016 profile, with small loss of material, up to 0.2m, between 50m and 90m. From 90m to 180m chainage, the beach level has increased by 0.3m compared to the March 2016 profile. Between 180 and 210m chainage the rocks at the bottom of the beach are exposed. The January 2017 post-storm survey shows a large loss of up to 0.8m on the upper beach between 10m and 90m chainage, with a corresponding increase in beach levels of up to 0.3m on the lower beach between 90m and 170m chainage. The October 2016 profile is relatively high on the upper beach and medium on the middle/lower beach compared to the range recorded from previous surveys. The January 2017 profile is medium on the upper/middle beach but relatively high on the lower beach compared to the range recorded from previous surveys. At **1dSBN2,** the beach is characterised by a shifting berm in the profile, which can form on the upper or lower beach. In October 2016, the beach level at the toe of the seawall had increased by 0.5m. The whole profile shows accretion, particularly in the upper and lower beach, with the greatest increase of 0.6m pushing the toe of the beach over the rocks by around 10m. From 130m chainage, the rocks at the bottom of the beach are exposed to the end of the survey. The January 2017 post-storm survey shows erosion of up to 0.8m on the upper beach between chainage 10m and 30m, with the formation of a berm up to 0.6m high between chainage 30m and 60m. The lower beach also shows erosion of up to 1m from chainage 60m to the end of the survey at 110m. The October 2016 profile is medium to high compared to the range recorded from previous surveys, whilst the January 2017 post-storm profile is low on the upper beach and medium along the rest of the profile. The October 2016 survey shows that the beach at profile **1dSBN3** has experienced up to 0.2m erosion	The beach profiles in October 2016 all show that beach building processes have dominated over the summer months. All the profiles are dominated by accretion and are relatively high compared to the range of previously recorded surveys. Profile 1dSBN3 varies slightly with erosion on the upper beach, but the profile remains relatively high. The January 2017 profiles show draw down of sediment in response to the storm surge. The profiles match the pattern shown in the corresponding topographic survey with profiles 1dSBN1 and 1dSBN2 showing material being drawn down from the top to bottom of beach, and profiles 1dSBN4 and 1dSBN5 showing material moving offshore with erosion along the entire profiles. Profile 1dSBN3 and the topographic survey both show accretion in the centre of the bay suggesting there may be some movement of sediment from the ends of the bay into the centre. The result of the January 2017 storm surge is that beach levels are low at the southern end of the bay and low-medium at the northern end, but the highest on record in the centre. **Longer term trends:** The observed trends in the topographic plots and beach profiles point to overall stability with seasonal fluctuations.

Survey Date	Description of Changes Since Last Survey	Interpretation
	at the base of the seawall at 15m chainage since March 2016. The erosion continues to chainage 90m, seawards of here there has been accretion of up to 0.7m. The effect has been to flatten the gradient of the beach. The January 2017 post-storm survey shows accretion along the whole profile, with an increase of 0.4m at the toe of the seawall, minor changes between 30m and 60m, and then increasing accretion seawards of up to 0.5m. The October 2016 profile is in the middle of the range recorded from previous surveys except at the toe of the beach where it is high. The January 2017 post-storm survey follows the same pattern, and is the highest recorded profile from chainage 100m seawards. There has been little change in the profile at **1dSBN4** at the base of the seawall with the rocks remaining exposed between chainage 25m and 60m. The rest of the October 2016 profile shows around 0.2m of accretion compared with the March 2016 survey. The January 2017 post-storm survey shows a drop in beach level of up to 0.5m with the rocks on the upper beach exposed by a further 5m. The October 2016 profile is relatively high compared to the range recorded by previous surveys, whilst the January 2017 profile is relatively low, in particular between chainage 90m and 110m where it is the lowest on record. On profile **1dSBN5,** there has been accretion along the whole beach between the March 2016 and October 2016 surveys, with an increase of 0.2m at the toe of the rock armour and up to 0.3m on the lower beach. There has been little change in the middle of the beach between chainage 60m and 100m. The January 2017 post-storm survey shows erosion of up to 0.5m from the toe of the defence to the end of the survey at chainage 120. The October 2016 survey is the highest on record, whilst the January 2017 post-storm survey is relatively low at the toe of the defence but in the middle of the recorded range along most of its length.	

Survey Date	Description of Changes Since Last Survey	Interpretation
	Topographic Survey: Scarborough North Bay is covered by an annual topographic survey, which was carried out in October 2016. In addition, a post-storm survey was carried out in January 2017. Data have been used to create a DGM (Appendix B - Map 4 and 16) with GIS for both surveys. The GIS has also been used to calculate the differences between the Full Measures topographic survey DGM (Autumn 2016) and the earlier topographic survey DGM (Autumn 2015), and the differences between the post-storm topographic survey DGM (January 2017) and the October 2016 DGM, with 5m resolution raster grids (as shown in Appendix B – Map 11 and 17), to identify areas of erosion and accretion. Appendix B - Map 11 (October 2015 to October 2016) shows that erosion of up to 1m dominated in the centre of the bay. The southern third of the bay is dominated by accretion in the middle beach with some erosion on the upper beach, and generally little change on the lower beach. The northern third of the bay is more patchy with some erosion on the upper beach, but the middle and lower beaches predominantly accreting. The post-storm January 2017 survey shows a reversal of these trends. The centre of the bay is dominated by accretion, with the northern and southern thirds of the bay dominated by erosion. The southern third in particular shows consistent erosion across the whole beach, whilst the northern third is more patchy with the erosion concentrated in the upper beach.	

2.6 Scarborough South Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
17th October 2016	**Beach Profiles:** Scarborough South Bay is monitored by four beach profiles, between the harbour in the north and the Spa Complex in the south (Appendix A). Sediment recycling took place in November 2016 after the Full Measures survey had been carried out in October 2016 to address an accumulation of sediment at the north end of the bay and very low beach levels in front of Scarborough Spa. The comparisons of short-term change are between March and October 2016. At profile, **1dSBS1** there has been very little change since March 2016 with most of the profile showing less than ±0.1m of change. The exception is the middle beach between chainage 60m and 140m where there has been up to 0.2m of accretion. The October 2016 profile is relatively high compared to the range recorded by previous surveys. The beach at profile at **1dSBS2** has remained stable with changes limited to ±0.2m. The upper beach between the seawall and chainage 130m shows accretion with slight erosion between chainage 130m and 180m. The lower beach shows accretion covering the rock outcrops exposed on the March 2016 survey from chainage 180m seawards. The October 2016 profile is relatively high through the upper and middle beach and in the middle of the range previously recorded for the lower beach. At profile **1dSBS3** there has been a loss of less than 0.2m of sand at the toe of the seawall. The rest of the profile shows accretion of up to 0.3m, with the depression between the two lower beach berms on the March 2016 infilled. Overall, the October 2016 profile is at a medium-high level compared to the range recorded by previous surveys. Profile **1dSBS4** shows erosion at the base of the seawall of up to 0.7m exposing the rock outcrop, which is not uncommon for this profile. From chainage, 40m to the end of the profile there has been accretion of up to 0.5m. The October 2016 profile is relatively low at the toe of the seawall compared to the range recorded by previous surveys, the rest of the profile is at a medium-high level with the section between chainage 100m and 200m being the highest recorded level.	The level of the beach in the profiles is high-medium compared to the range recorded in previous years. All of the profiles show accretion, with the southerly profiles (1dSBS3 and 1dSBS4) also showing erosion at the toe of the seawall. The short term change plot also shows variable erosion and accretion, matching the profiles. The accumulations in the mid-beach at the northern end is likely to be due to the action of constructive waves through the summer. The cliff top change markers have indicated negligible change at most locations markers, with, 0.1-0.3m loss recorded at two locations. **Longer term trends**: The beach is regularly re-profiled with sediment moved from near the harbour to the frontage of The Spa, but sediment naturally moves northwards towards the harbour. Table C3 shows that since March 2010 the majority of the cliff erosion profiles have shown negligible recession. Profiles 11 and 12 show erosion of 0.6 and 0.5 m/year respectively. These points are at the rear of a mudslide system which experiences periodic reactivation or headscarp collapse.
	Topographic Survey:	

Survey Date	Description of Changes Since Last Survey	Interpretation
	Scarborough South Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 5) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2016) and the earlier topographic survey DGM (Autumn 2015), with 5m resolution raster grids (as shown in Appendix B – Map 12), to identify areas of erosion and accretion. Appendix B - Map 12 shows that the northern half of the bay has seen little change in beach levels with the exception of the area immediately adjacent to West Pier where there are alternating shore parallel areas of accretion and minor erosion. In the southern part of the bay, the upper beach is dominated by erosion. The middle and lower beach are more patchy, generally showing little change or small amounts of accretion.	
	Cliff-top Survey: Thirteen ground control points have been established at Scarborough South Bay, extending from South Bay to Cayton Bay for the purposes of cliff top monitoring. The separation between any two points is around 300 m. The cliff top surveys at Scarborough South Bay are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Between March and October 2016, ten of the thirteen locations showed change of less than ±0.1m. Two markers, numbers 7 and 12 both had erosion of >0.1m over the summer of 2016. The recession rates calculated for the period from March 2010 to October 2016 give a picture of the change over the longer term. Eleven of the markers have a recession rate of less than 0.1m/yr. Markers 11 and 12 are the only markers showing a higher rate of 0.6m/yr. and 0.5m/yr. respectively. Appendix C provides results from the October 2016 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the March 2010 baseline survey. Short-term and long term average recession rates are also provided.	

2.7 Cayton Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
19th October 2016	**Beach Profiles:** Cayton Bay is covered by three beach profile lines, distributed between Tenants' Cliff and the south of Cayton Sands (Appendix A). The cliff face at profile **1dCY1** (Tenant's Cliff) is vegetated and was difficult for the surveyors to access resulting in poor data in the top of the profile. In the rest of the profile, there was little change as far as 25m chainage between March and October 2016 with the rock exposed. From 25m to 70m chainage, the beach level has dropped by up to 0.2m. Between 70m and 120m chainage, a berm has accreted with up to 0.8m rise in beach levels since March 2016; this has covered the rock outcrops by around 10m. From 120m to the end of the survey at 170m rocky exposure have remained stable. Overall, the October 2016 profile is relatively low in the upper beach but high in the mid and lower beach compared to the range recorded in previous surveys. Profile **1dCY2** (close to former pumping station) has remained stable over the cliff up to chainage 120m. There has been accretion along the full beach profile, although there is very little change in the mid-beach area. The upper beach has accreted by up to 0.4m and the lower beach has accreted by up to 0.7m. The October 2016 profile is relatively high compared to the range recorded in the previous surveys, particularly on the lower beach where it is the highest recorded from chainage 260m seawards. There has been little change across the cliff section of profile **1dCY3** (600m southeast of the pumping station) and rocks at the toe of the cliff to chainage 140m. Two berms of up to 0.6m in height have formed between chainage 140m and 170m, and 190m and 230m. There has been erosion of up to 0.4m at the toe of the beach. Overall, the October 2016 profile is at a medium-high level compared to the range recorded from previous surveys.	The beach profiles have been stable overall with evidence of the formation of beach berms. The plot of difference between Autumn 2015 to Autumn 2016 surveys shows variability in the erosion and accretion in the bay. The main change was erosion on the upper beach and accretion on the mid beach. The cliff top survey data shows a small amount of recession of less than 0.3m in the centre of the bay (markers 3, 4, and 5) during the summer of 2016. **Longer term trends:** The pattern of migrating sand bars has remained consistent since 2010 indicating seasonal variation in beach level with no net change.
	Topographic Survey: Cayton Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 6) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2016) and the earlier topographic survey DGM (Autumn	

Survey Date	Description of Changes Since Last Survey	Interpretation
	2015), with 5m raster grids (as shown in Appendix B – Map 13), to identify areas of erosion and accretion. Appendix B - Map 13 shows that the observed changes are weakly shore parallel. During 2016, the upper beach generally underwent erosion, whilst the mid to lower beach underwent accretion. The distribution is patchy however so the patterns of change vary across the beach.	
	Cliff-top Survey: Eight ground control points have been established within Cayton Bay for the purposes of cliff top monitoring. The separation between any two points is typically around 200 m. The cliff top surveys at Cayton Bay are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. The results of the cliff top survey are shown in Table C4. Between March and October 2016, four of the eight profiles showed no discernible change (within the ±0.1m accuracy of the survey). Markers 3, 4, 5, and 8 show erosion of up to 0.3m, but the thick vegetation on this cliff means the result could be error. Long-term erosion rates calculated using data collected since November 2008 show change either within the margin of error or advance, indicating survey difficulties, at most points. Markers 2, 4 and 6 show erosion rates of 0.6m/yr., 0.4m/yr. and 0.2m/yr. respectively. Appendix C provides results from the October 2016 survey showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey.	

2.8 Filey Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
20th – 22nd September 2016	**Beach Profiles:** Filey Bay is covered by five beach profiles between Filey Sands and Speeton Sands (Appendix A). At profile **1dFB1** fronting Filey seawall, the upper beach has accreted by 0.5m at the toe of the seawall (chainage 20m to 40m). Between 40m and 150m chainage there has been a small amount of accretion of <0.2m. From 150m seawards the profile has generally eroded, with the largest change between chainage between 150m and 190m where a depression up to 0.3m deep has formed. The profile is among the highest recorded for the upper beach, but is low-medium for the lower beach compared to the range recorded by previous surveys. The changes observed at profile **1dFB2** (located to the north of Primrose Valley Holiday Village) since March 2016 are very small. There has been accretion of up to 0.3m across the whole beach with the largest gains on the upper beach between chainage 70m and 100m. The profile is the highest recorded and is similar to the September 2015 and March 2016 profiles. At profile **1dFB3**, near Flat Cliffs, the upper and mid beach has generally been accreting by up to 0.4m between chainage 40m and 210m, with the small berm in the mid beach growing slightly. The lower beach seawards of 210m has eroded by up to 0.4m, with the berm moving seawards by c.30m. The September 2016 profile is the highest on record for the upper and mid beach, and in the middle of the range recorded from previous surveys for the lower beach. Profile **1dFB4** at Hunmanby Gap, has accreted over the whole beach, in particular on the upper beach between chainage 30m and 140m where accretion of up to 0.9m has occurred forming a berm. The September 2016 profile is the highest on record for most of its length compared to the range recorded from previous surveys. At profile **1dFB5** (located close to Reighton Gap), there has been little change to 225m chainage since March 2016. The majority of the beach profile shows accretion of up to 0.8m, with the depression at 400m chainage in the March 2016 survey being infilled. The exception to the accretion is the formation of a depression between chainage 280m and 320m, and erosion of the toe of the beach seawards of 420m. Overall, the September 2016 profile is in the middle to high end of the range recorded by the	The beach profiles are dominated by accretion, with some erosion on the lower beach at profiles 1dFB1, 1dFB3, and 1dFB5. The beach levels are generally high-medium compared with the range recorded from the previous surveys. The topographic change map shows Filey Bay has shore parallel bands of accretion and erosion in the associated with migrating berms and very little change in the north. The cliff top survey data provided in Table C5 shows erosion at several monitoring points. The largest change was at markers 12, 12A, 18, and 23 where 0.5m to 0.7m was lost over the summer of 2016. **Longer term trends**: Past trends dominated by migrating sand bars continue to the present day.

Survey Date	Description of Changes Since Last Survey	Interpretation
	previous surveys, the mid beach showing the highest recorded levels. .	
	Topographic Survey (Filey Bay): Filey Bay is covered by an annual topographic survey. In addition to the annual survey of Filey Bay, a smaller area fronting Filey Town is re-surveyed every six months to document seasonal patterns. Data have been used to create a DGM (Appendix B – Map 7) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2016) and the earlier topographic survey DGM (Autumn 2015), with 5m resolution raster grids (as shown in Appendix B – Map 15) to identify areas of erosion and accretion. Appendix B - Map 15 shows the majority of the northern part of the bay from Filey Brigg to Primrose Valley shows very little change in beach levels. There are some shore parallel patches of erosion on the upper and lower beach in front of Filey Town, and accretion on the upper and mid beach immediately to the south of Filey Brigg. The southern section of the bay from Primrose Valley shows greater magnitude of change with shore parallel bands of erosion and accretion. The general pattern is for a very narrow band of erosion at the toe of the cliffs with further erosional bands in the mid beach and at the toe of the beach. Bands of accretion tend to occur on the upper beach and mid-lower beach. Overall, there are more areas of accretion than erosion and the area of greatest change is between Hunmanby Gap and Reighton Gap. **Topographic Survey (Filey Town):**	
	Cliff-top Survey: Twenty-eight ground control points have been established within Filey Bay for the purposes of cliff top monitoring. This includes the installation of three additional locations in September 2010: points 12A (as a replacement for point 13, which can no longer be accessed due to vegetation growth), 24 & 25 (to the north of Filey Bay at Filey Brigg). A further replacement for monitoring point 13, 13A, has been added in	

Survey Date	Description of Changes Since Last Survey	Interpretation
	2014. The maximum separation between any two points is nominally 300 m. The cliff top surveys at Filey Bay are undertaken every six months. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Between March and September 2016, nineteen of the ground control points showed no discernible change (within the ±0.1m accuracy of the survey). Five of the remaining points (markers 3, 7, 10, 11, and 21) had shown apparent recession of up to 0.2m. Markers 12, 12A, 18, and 23 showed more significant recession of 0.5m, 0.7m, 0.6m, and 0.6m respectively. Long term rates of change show only five markers have erosion with rates between 0.1m/yr. and 0.8m/yr. The largest erosion rate recorded is at control point 5, to the south of the Filey Town defences. Appendix C provides results from the September 2016 survey showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the baseline survey.	

3. Problems Encountered and Uncertainty in Analysis

Survey accuracy of beach/ cliff profiles
The aim of cliff monitoring data is to gain a reliable record of the frequency and magnitude of cliff top failures. Data are collected every six months, but previous surveys have had a low accuracy, meaning that survey error is typically greater than any measured short term change. It is possible that a more reliable pattern of change will be determined over the longer term. However, in the short term, more reliable assessments of cliff recession can be derived from analysis of time-series remote sensing data. Under this programme a high quality baseline survey, comprising LiDAR and aerial photography, was collected in 2010, a repeat survey was completed in 2012/13 and a second repeat survey is planned for 2015. These data will be analysed to give more accurate information on the behaviour of the cliffs in a separate report. More accurate estimates of long term cliff top change would be possible by comparing results from the current programme to historical aerial photography over the last 50 years.

A previous survey station has been buried under a newly installed man made embankment at Staithes A new survey station 4 has been installed. At Robin Hoods Bay, there was a large increase in VMP 5 due to deposited garden waste.

At Whitby, the cliff top of profile 1dWB2 was too heavily overgrown at the time of survey to safely access.

At Robin Hoods Bay, the surveyors noted there was continuous rock and gravel falls along the cliffs.

At Scalby in Scarborough North Bay the cliff edge was very overgrown resulting in areas that were unable to be surveyed.

During the survey of Scarborough South Bay the surveyors noted that the removal of sand from the north west corner of the beach and regrading elsewhere on the beach had just commenced. A follow up survey in November 2016 was carried out after the regrading works had been completed.

At Filey, the surveyor was unable to measure the start of profile 2 due to vegetation; the middle of profile 5 was not measured from chainage 63m to approx. 206m, due to vegetation. VMP12A was inaccessible due to heavy vegetation.

Cliff top erosion errors & data capture techniques
The cliff top surveys are in general assumed to have a limit of accuracy of ± 0.1m due to the techniques used and problems have been experienced in precisely locating the cliff edge, due to vegetation growth and the convex profile. Most profiles have now been monitored for six years, and a more reliable picture of change is now emerging that indicates very low rates of erosion, with only occasional and localised examples of erosion exceeding 0.5m/yr.

4. Recommendations for 'Fine-tuning' the Monitoring Programme

No changes are recommended at the present time.

5. Conclusions and Areas of Concern

The following points have been observed:

- The measurements of the Cowbar and Staithes cliff top show erosion of between 0.1 and 0.3m over the summer of 2016 at four stations. A further four stations were inaccessible due to a landslip on the headland suggesting there may have been significant recession in this area.

- Runswick Bay shows shore parallel changes, with erosion on the upper and lower beach and accretion in the middle.
- At Sandsend Beach, Upgang Beach and Whitby Sands accretion has been the dominant process over the summer of 2016 with beach levels at a relatively high level.
- At Robin Hoods Bay, the beach and cliff have remained stable with very little change over the summer of 2016. No discernible change has been registered by the cliff top markers and only one cliff recession marker shows substantial change in the long term record, and the majority of this change occurred in 2011.
- For Scarborough North Bay the October 2016 survey shows the beach remained stable with beach building processes dominating over summer resulting in relatively high beach levels. Following the January 2017 storm surge the beach showed drawdown with erosion dominating, however the centre of the bay underwent accretion. The resulting beach levels are low in the south, low-medium in the north, but the highest on record in the centre of the bay.
- At Scarborough South Bay, all the beach profiles show accretion over the summer of 2016 and are high compared to the previous profiles, especially in the mid beach, which also shows accretion in the short term difference plots.
- The Cayton Bay beach profiles show stability overall with evidence of the formation of beach berms. The pattern of migrating sand bars has remained consistent since 2010 indicating seasonal variation in beach level with no net change. The cliff monitoring showed a small amount of recession of <0.3m in the centre of the bay (markers 3, 4, and 5).
- The profiles at Filey Bay show stability overall. The profiles have all seen accretion, with some erosion at the toe of the beach. The profiles are among the highest recorded for these locations. The topographic difference plot shows very little change in the north but shore parallel bands of accretion and erosion in the south associated with migrating berms. There has been significant recession recorded at various points through the centre and south of the bay of between 0.5m and 0.7m (markers 12, 12A, 18, and 23). Marker 5 to the south of Filey Town remains the location with the highest erosion rate of 0.8m/yr. despite showing no signs of recession over the summer of 2016.

Appendices

Appendix A

Beach Profiles

Beach Profile

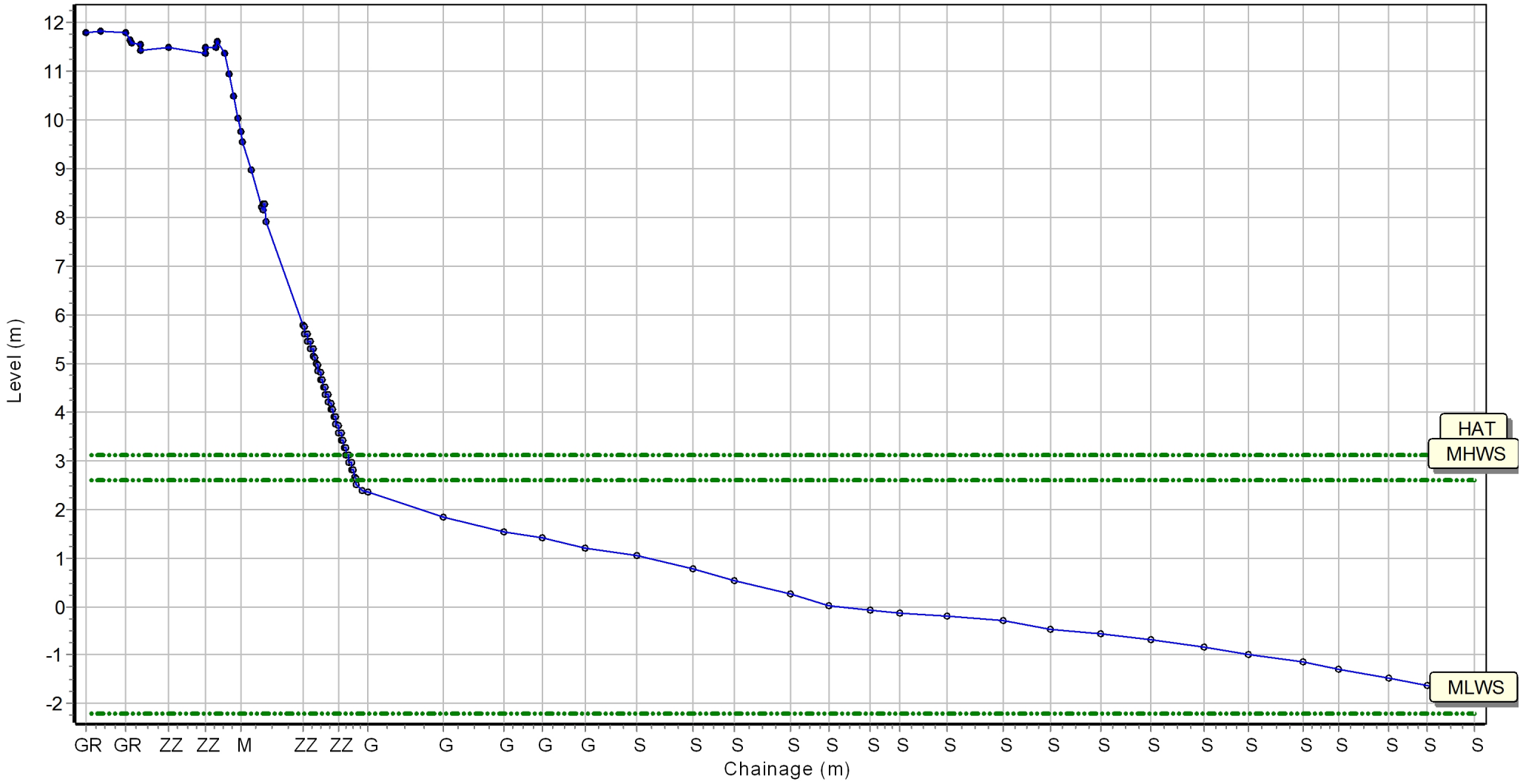
Location: **1dWB1**

Date: 21/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 486535.075 **Northing:** 512437.797 **Profile Bearing:** 32 from North



Beach Profile

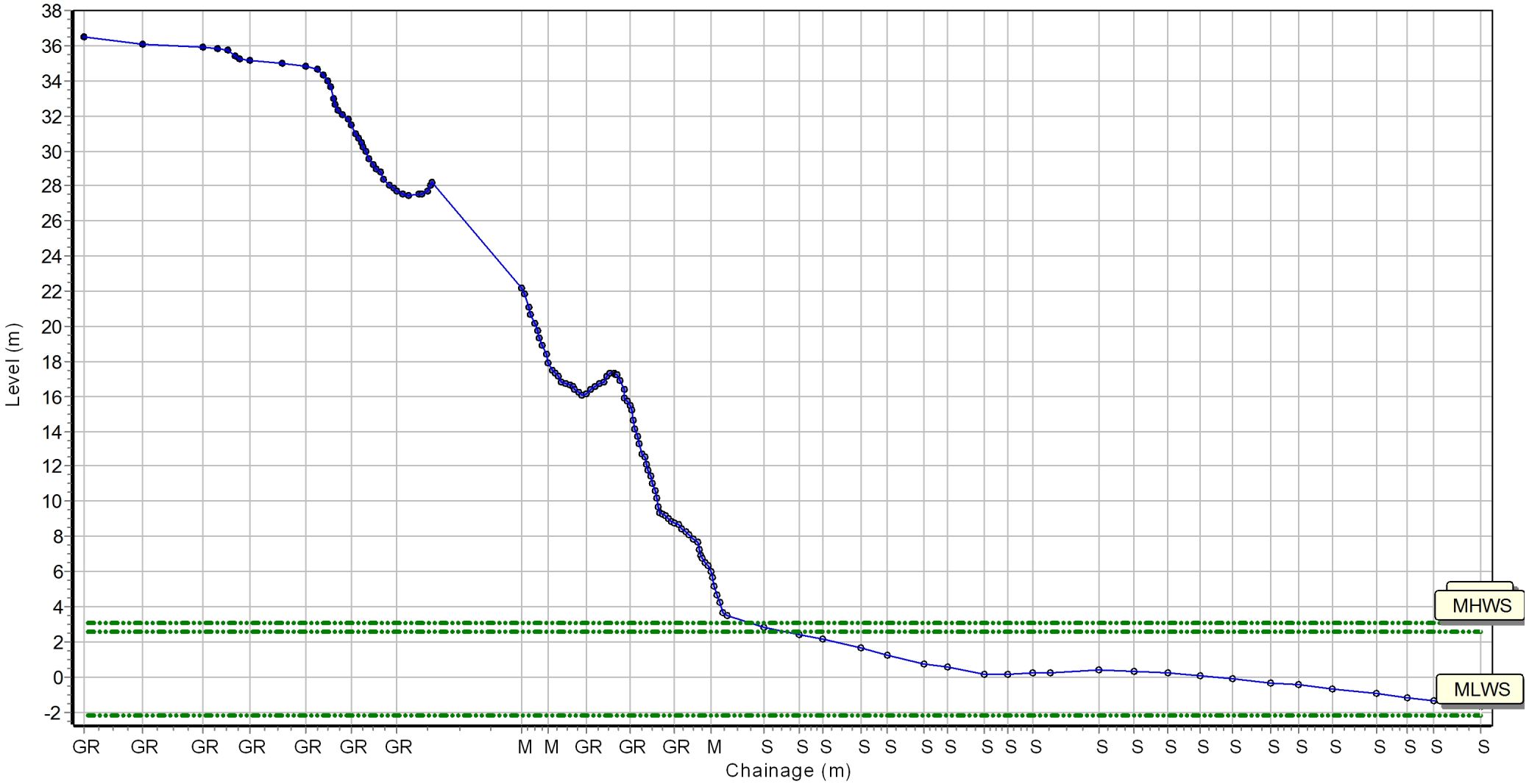
Location: **1dWB2**

Date: 21/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 487550.221 **Northing:** 511927.902 **Profile Bearing:** 16 from North



Beach Profile

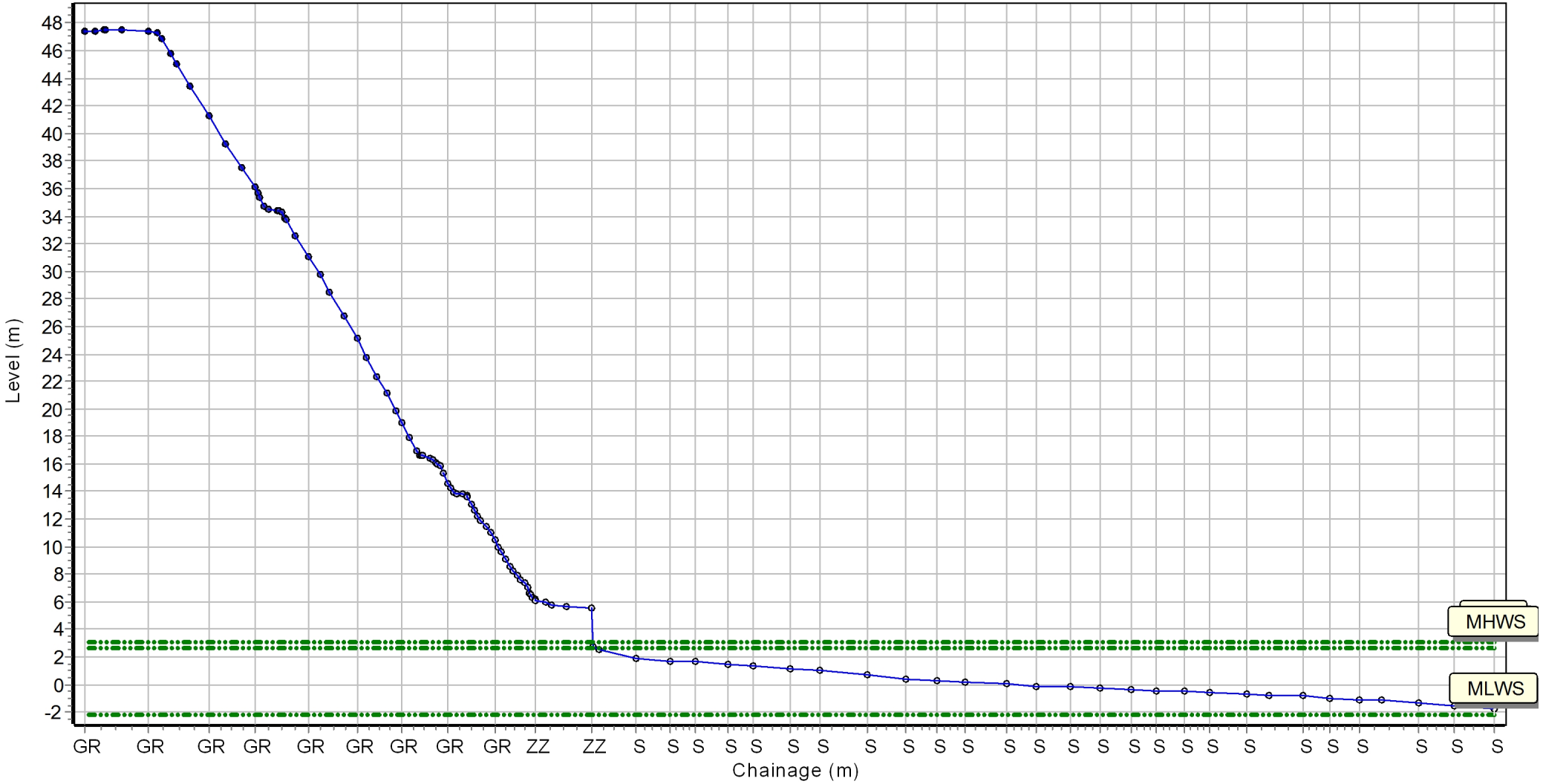
Location: **1dWB3**

Date: 21/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 488983.57 **Northing:** 511527.047 **Profile Bearing:** 19 from North



Beach Profile

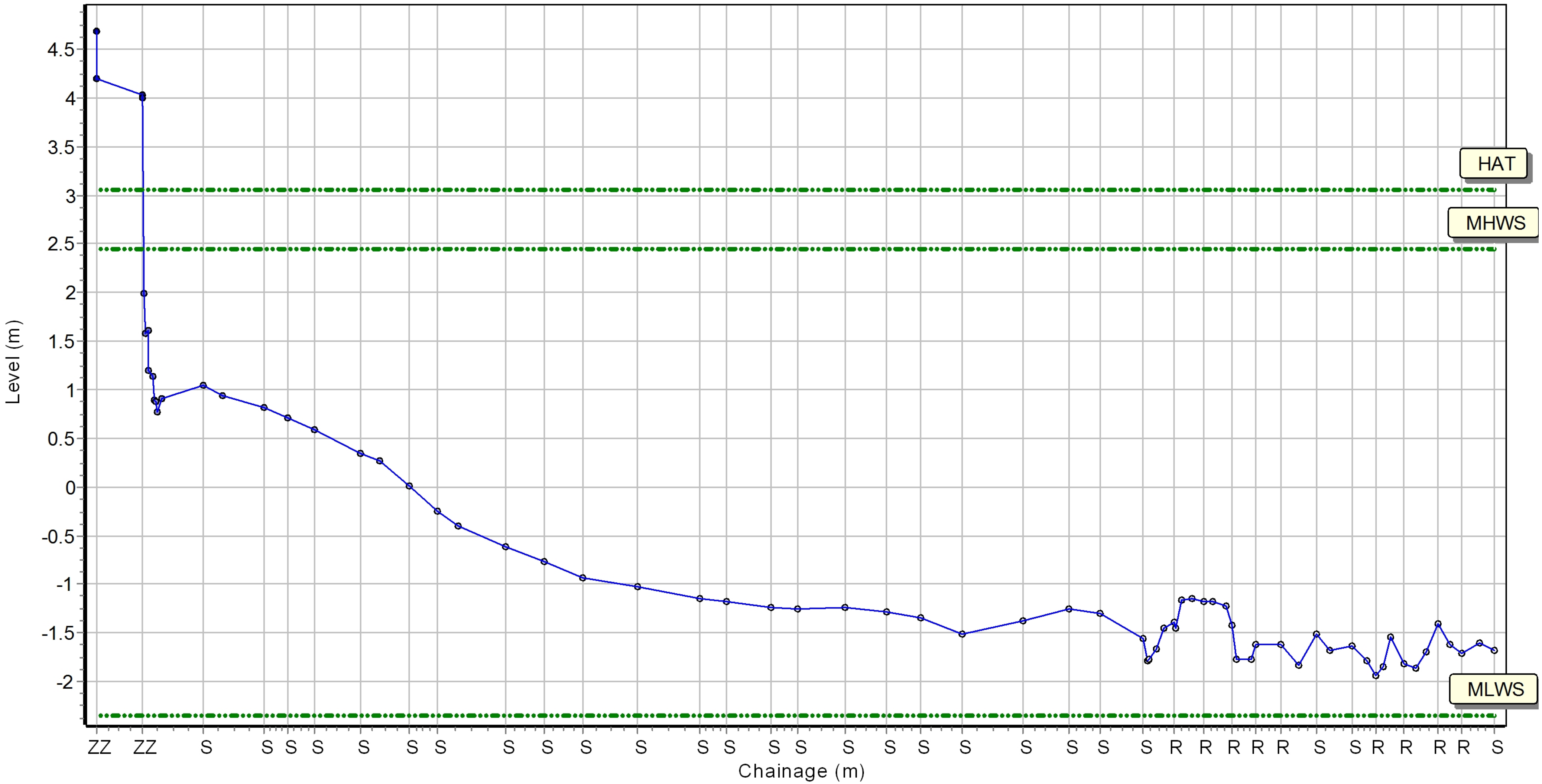
Location: 1dSBN1

Date: 18/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 503543.363 **Northing:** 490470.74 **Profile Bearing:** 79 from North



http://www.sandsuser.com **SANDS**

Beach Profile

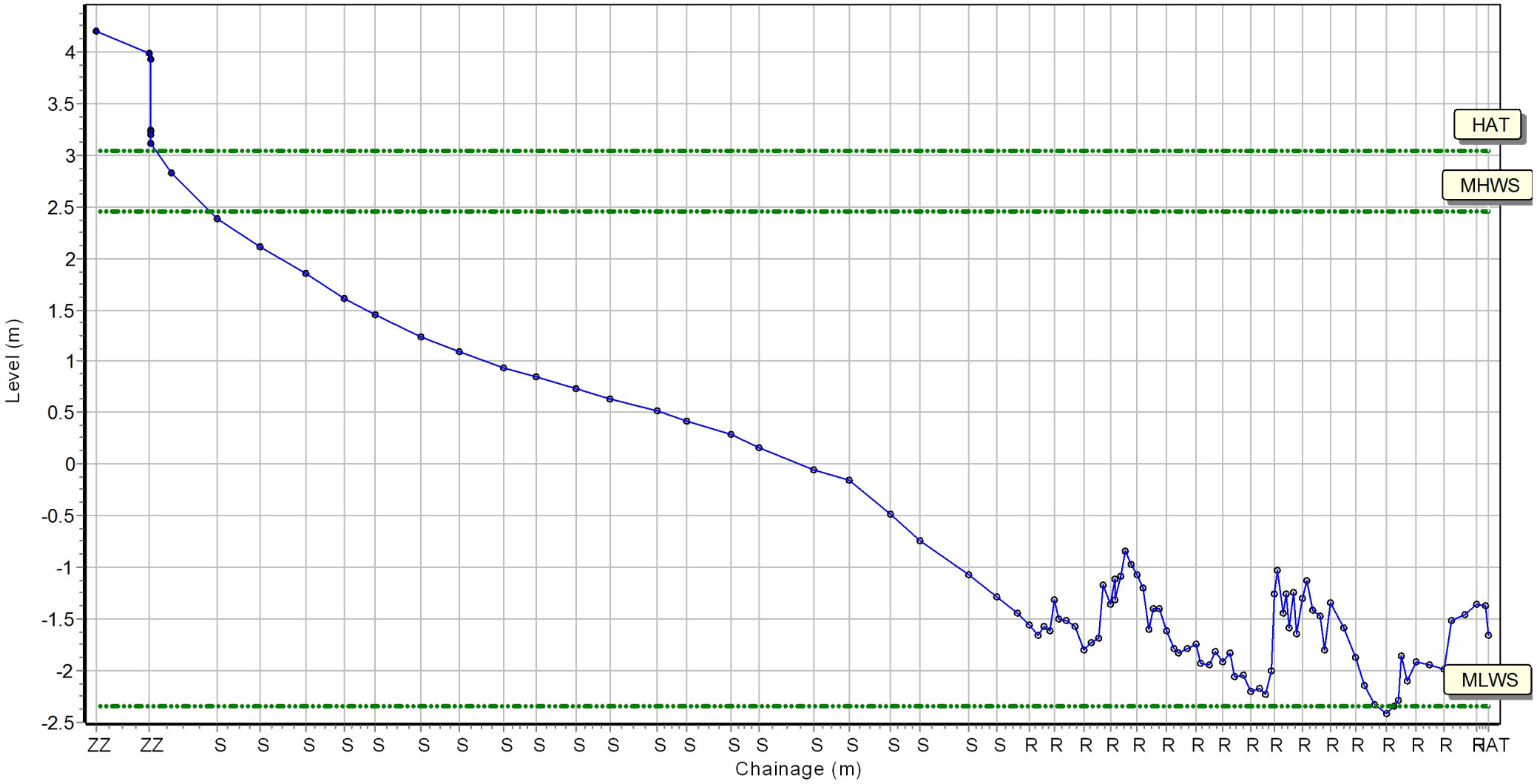
Location: **1dSBN2**

Date: 18/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 503616.346 **Northing:** 490135.674 **Profile Bearing:** 78 from North



Beach Profile

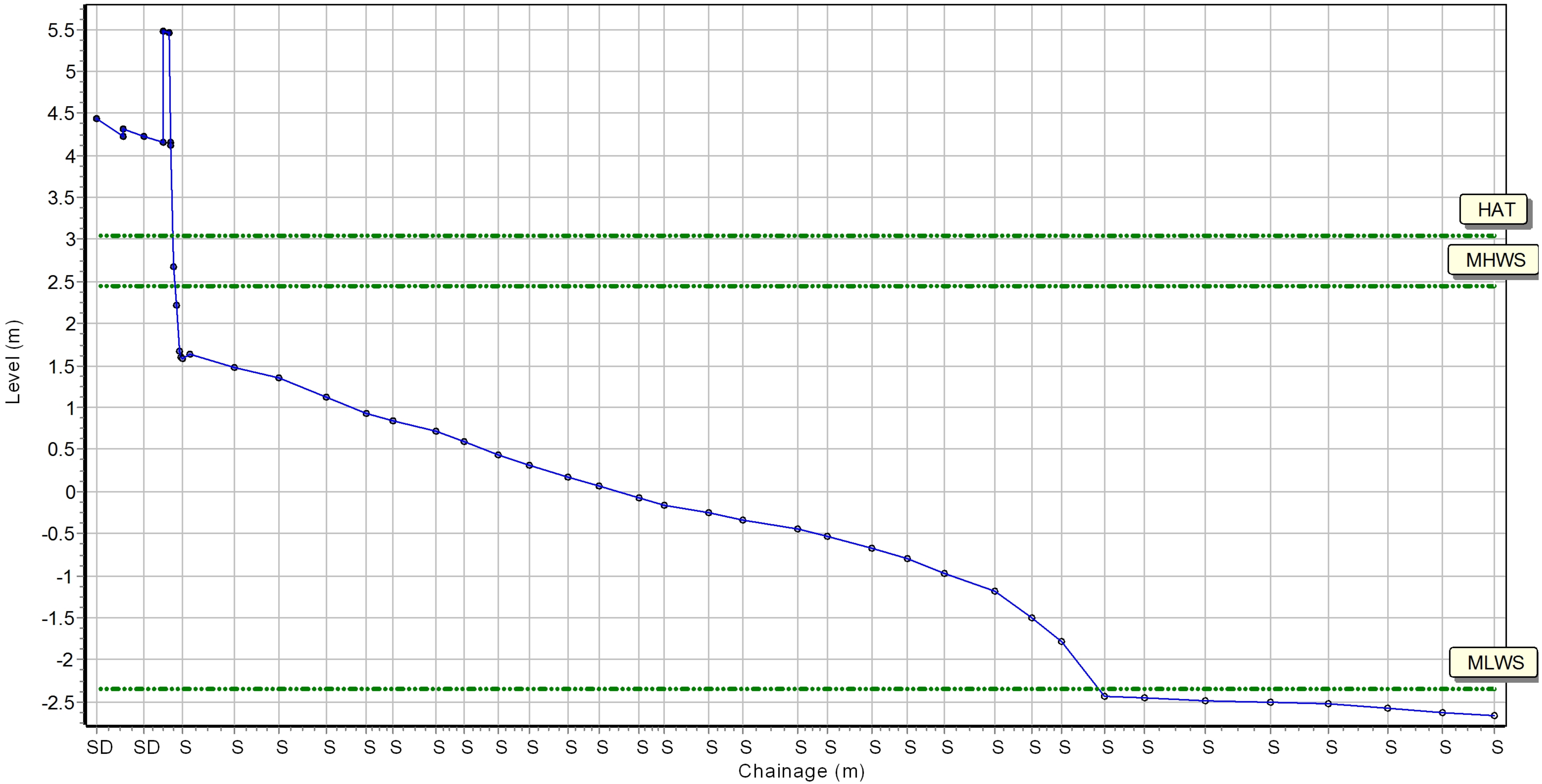
Location: **1dSBN3**

Date: 18/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 503803.958 **Northing:** 489708.315 **Profile Bearing:** 58 from North



http://www.sandsuser.com **SANDS**

Beach Profile

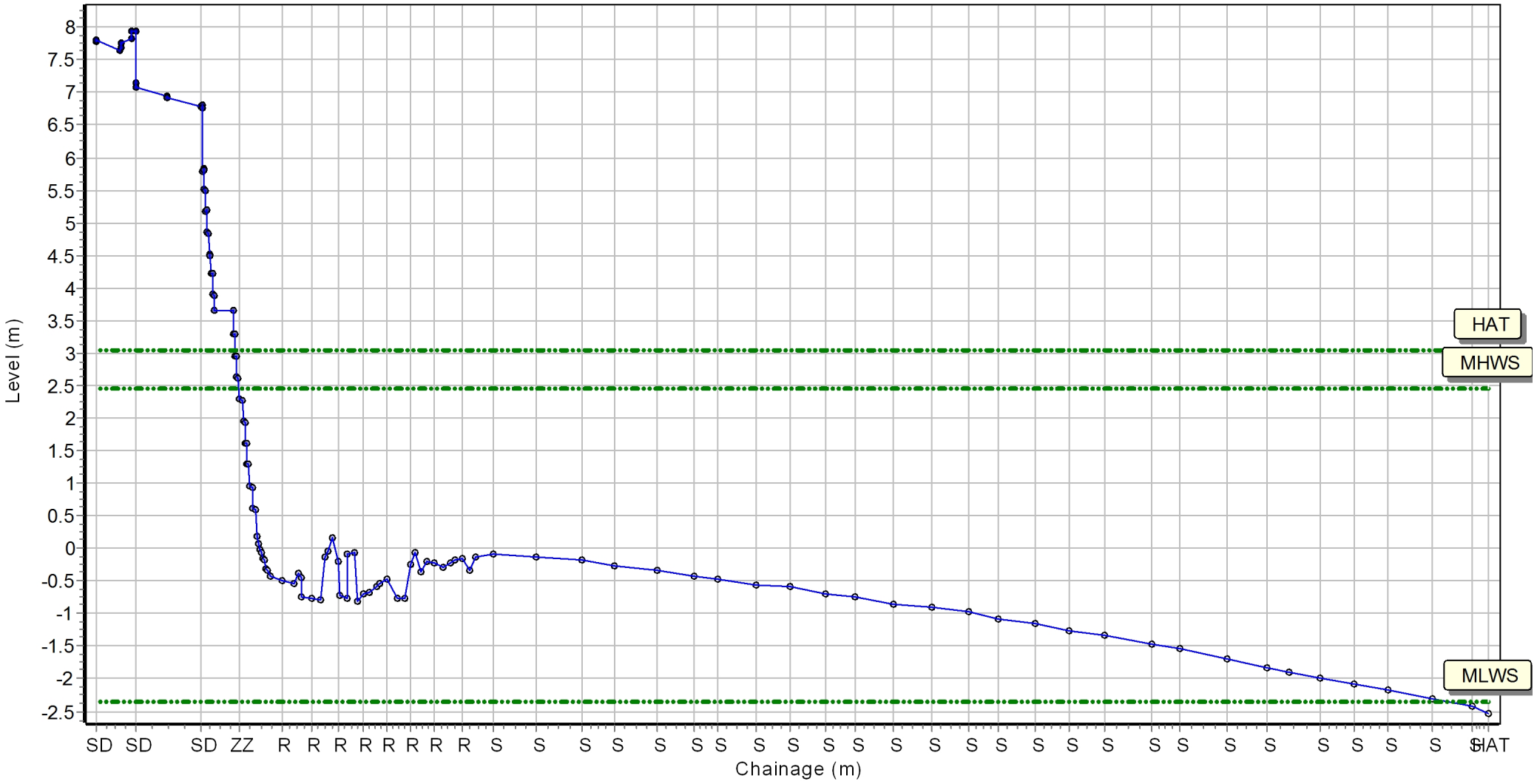
Location: **1dSBN4**

Date: 18/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504111.79 **Northing:** 489397.699 **Profile Bearing:** 38 from North



Beach Profile

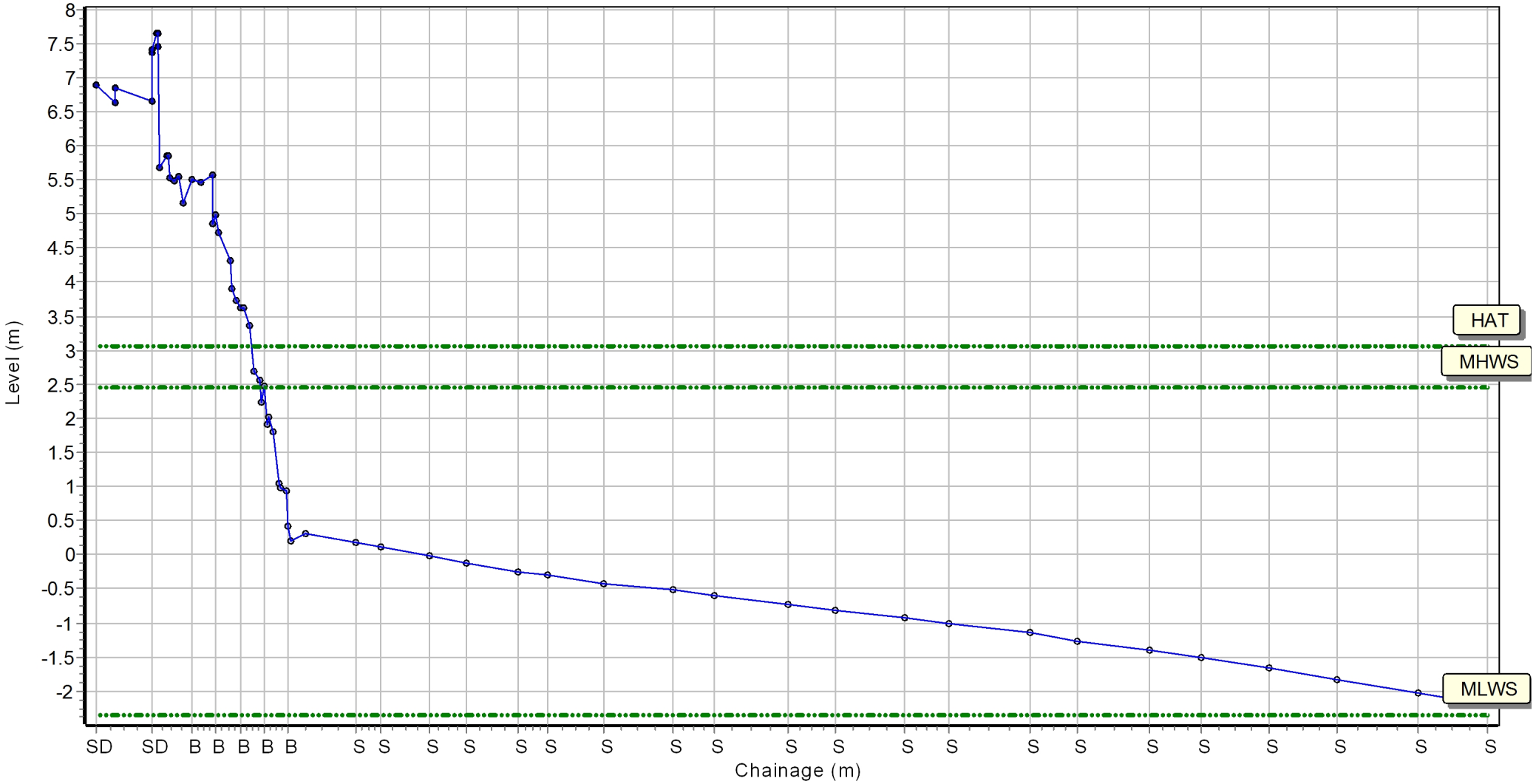
Location: **1dSBN5**

Date: 18/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504515.599 **Northing:** 489205.724 **Profile Bearing:** 14 from North



Beach Profile

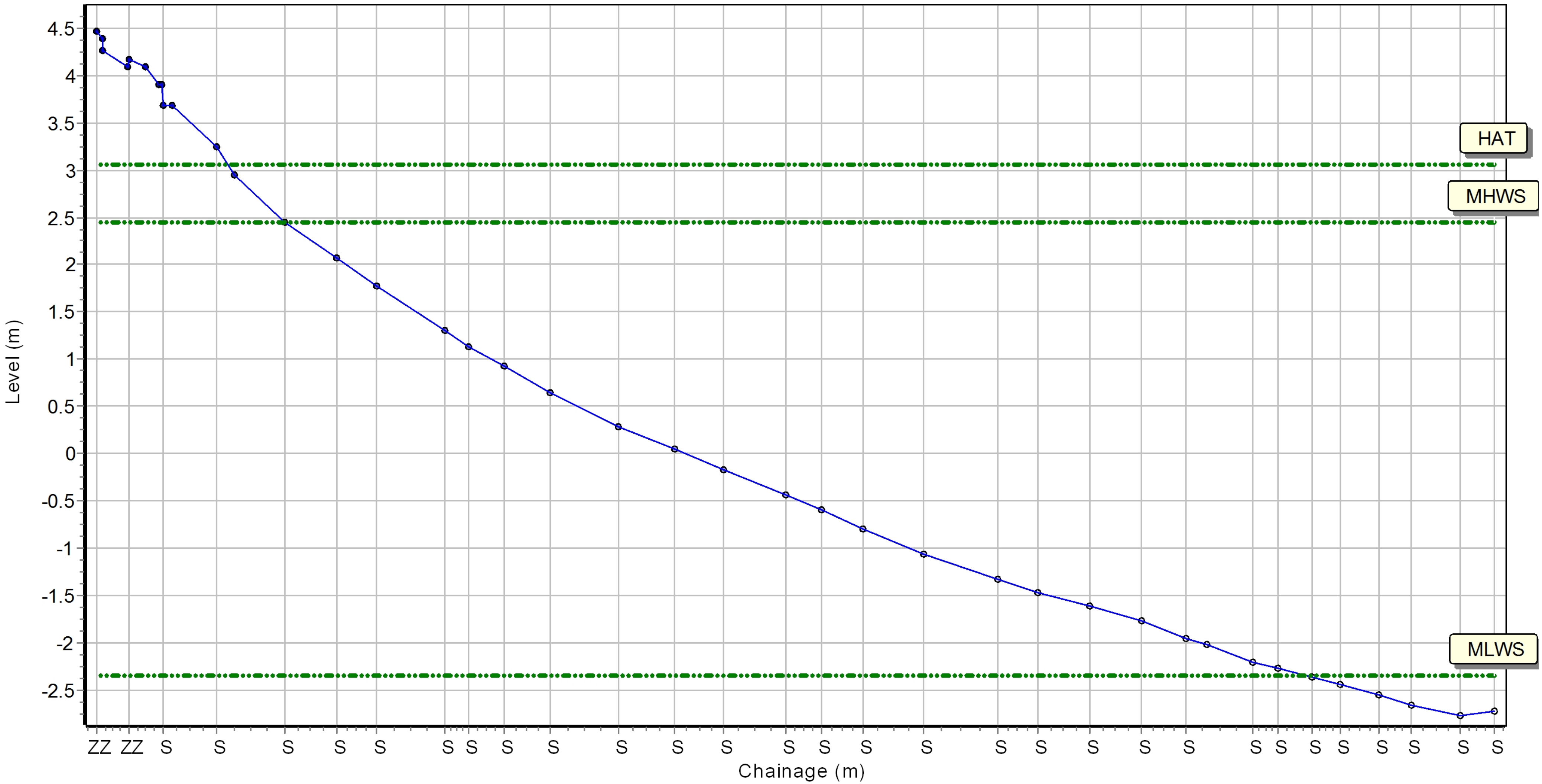
Location: 1dSBS1

Date: 17/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504544.727 **Northing:** 488604.814 **Profile Bearing:** 120 from North



Beach Profile

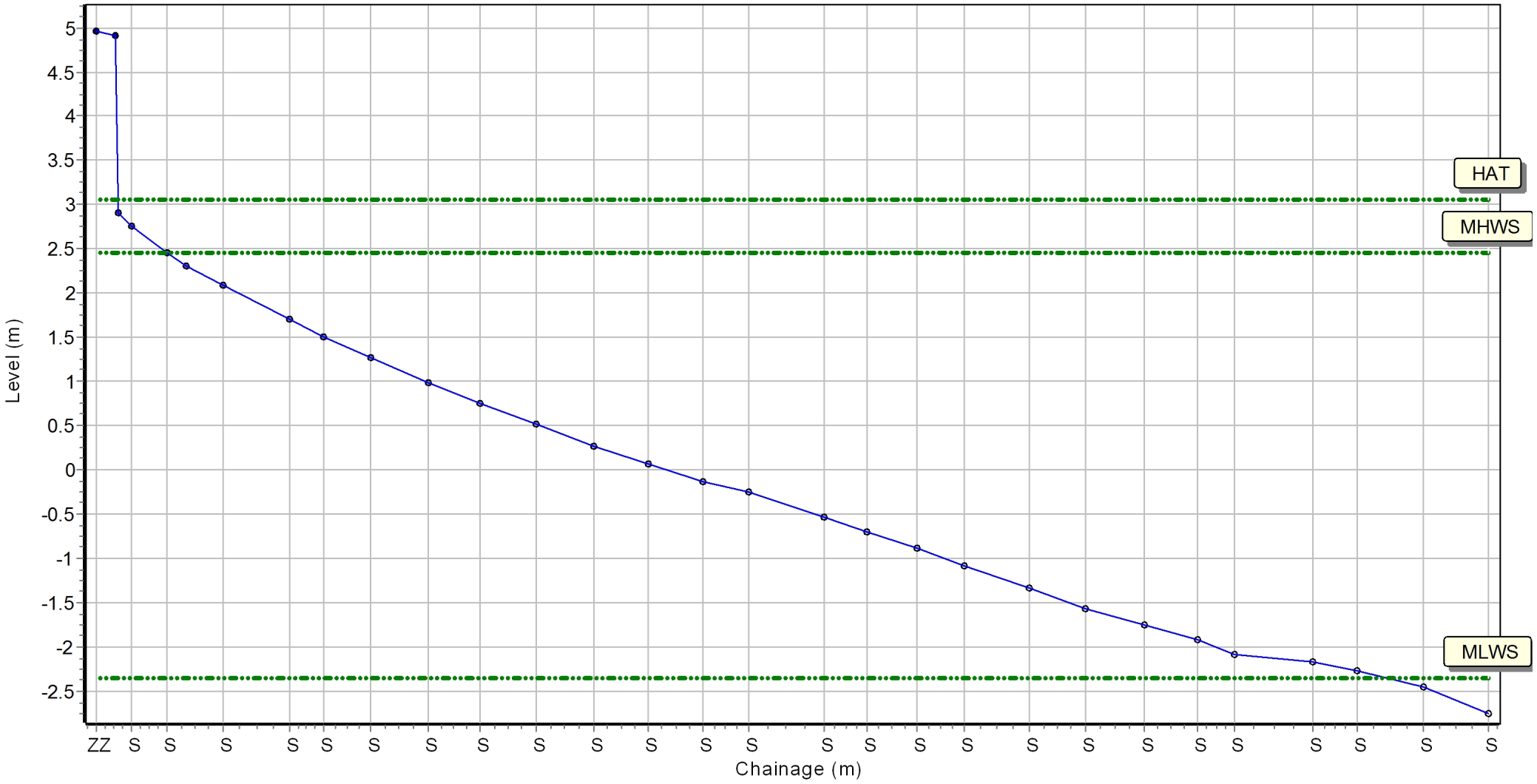
Location: **1dSBS2**

Date: 17/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504443.218 **Northing:** 488326.371 **Profile Bearing:** 105 from North



Beach Profile

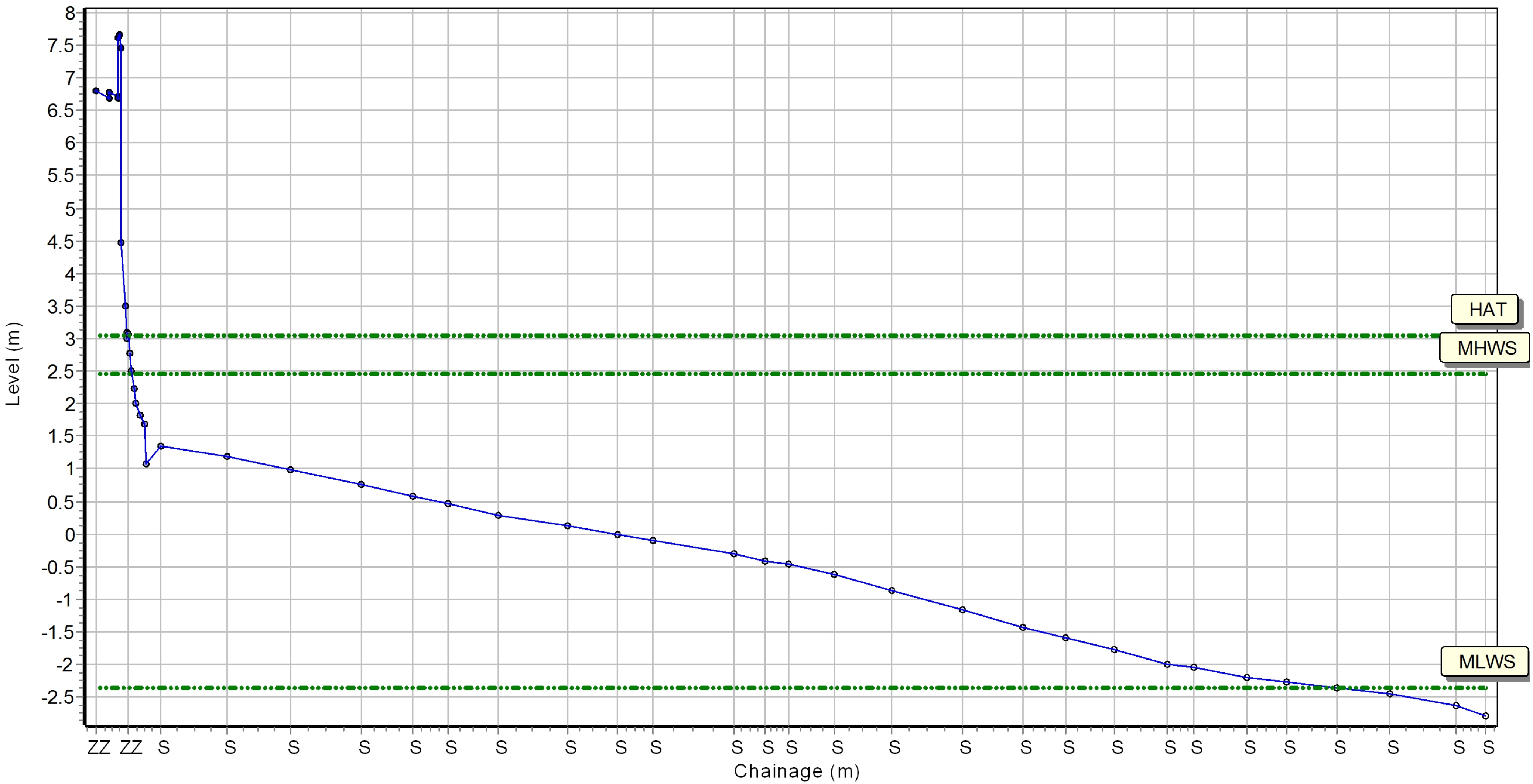
Location: 1dSBS3

Date: 17/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504423.086 **Northing:** 488057.66 **Profile Bearing:** 83 from North



Beach Profile

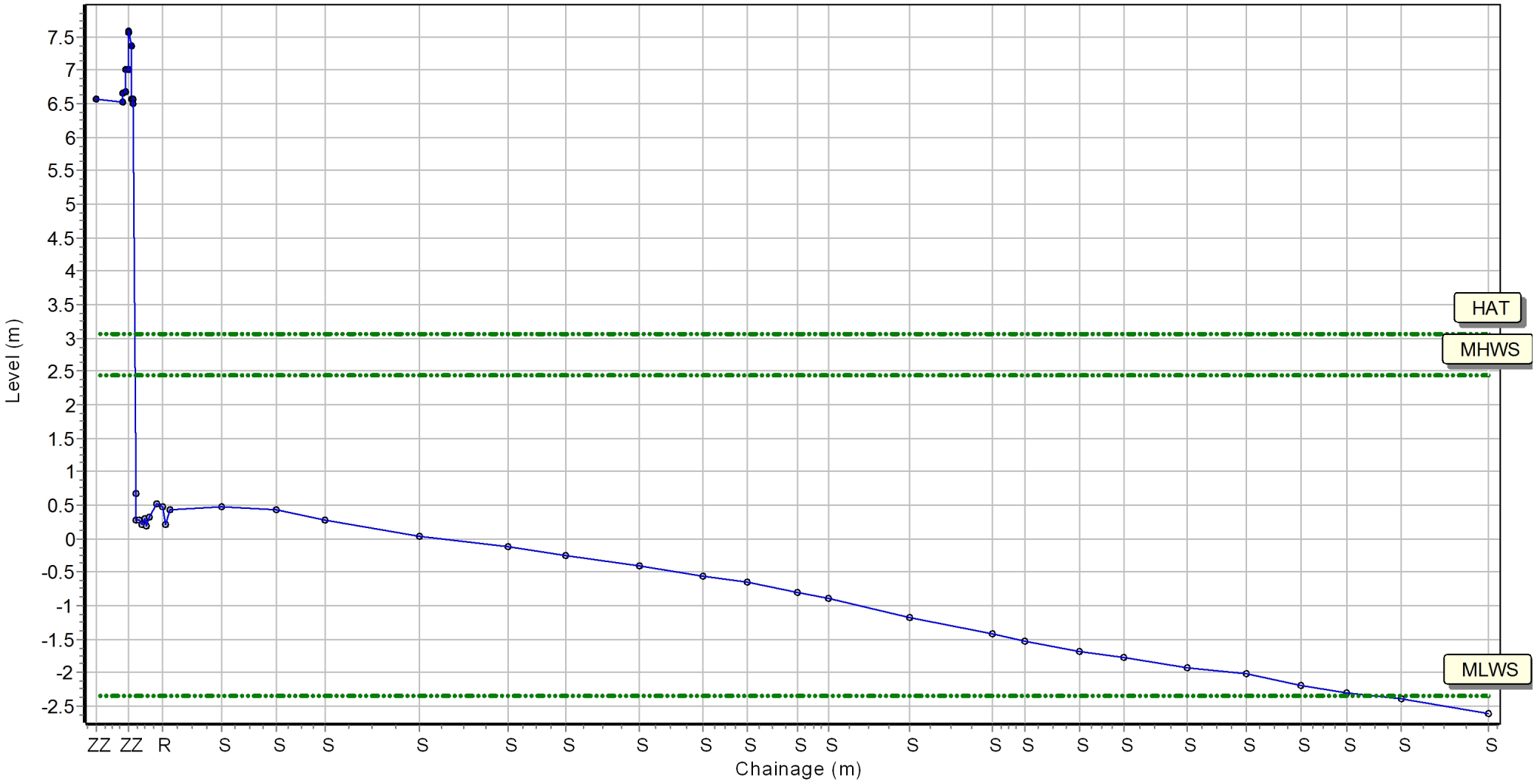
Location: **1dSBS4**

Date: 17/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504494.785 **Northing:** 487816.983 **Profile Bearing:** 74 from North



Beach Profile

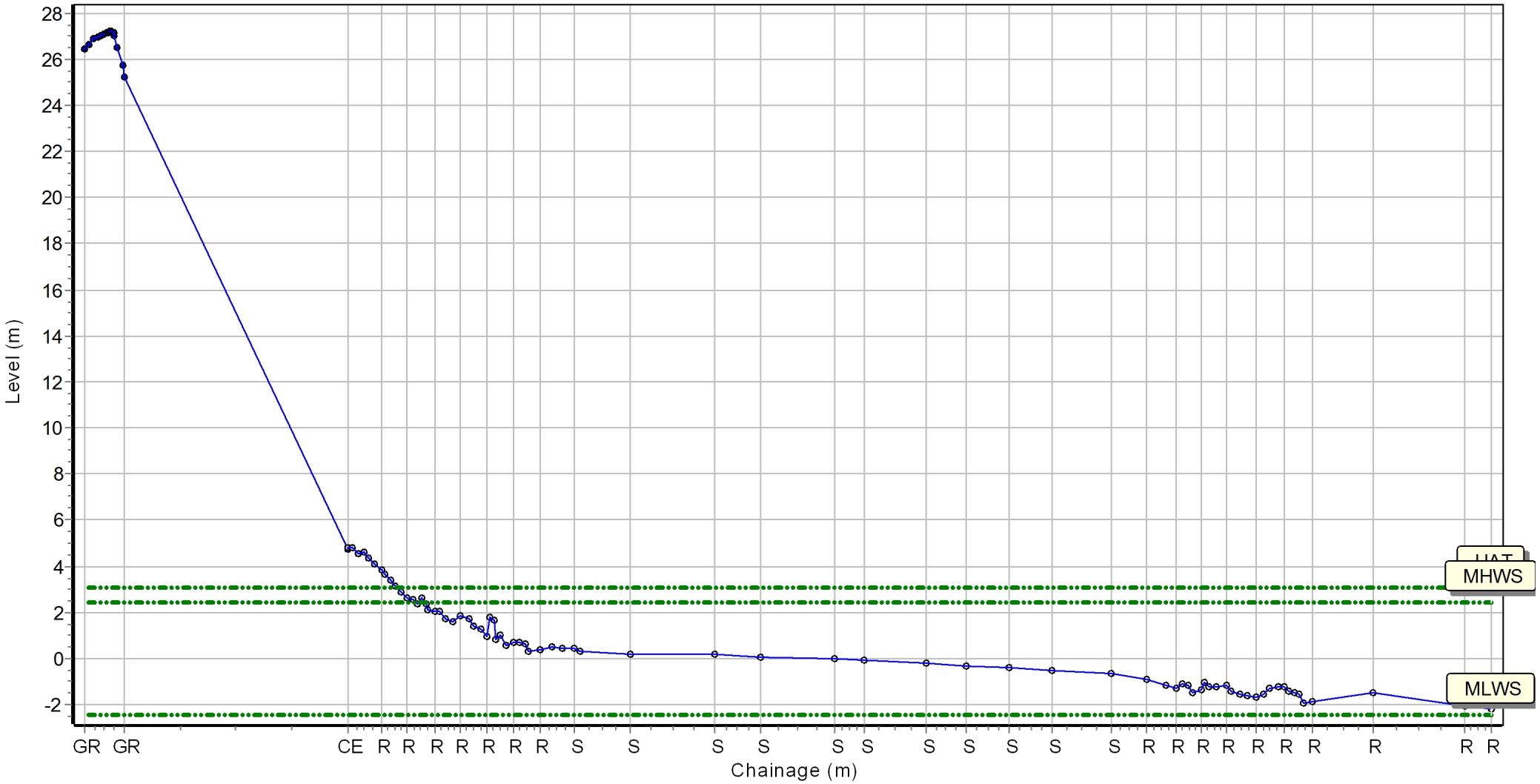
Location: **1dCY1**

Date: 19/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 506420.411 **Northing:** 484793.941 **Profile Bearing:** 43 from North



Beach Profile

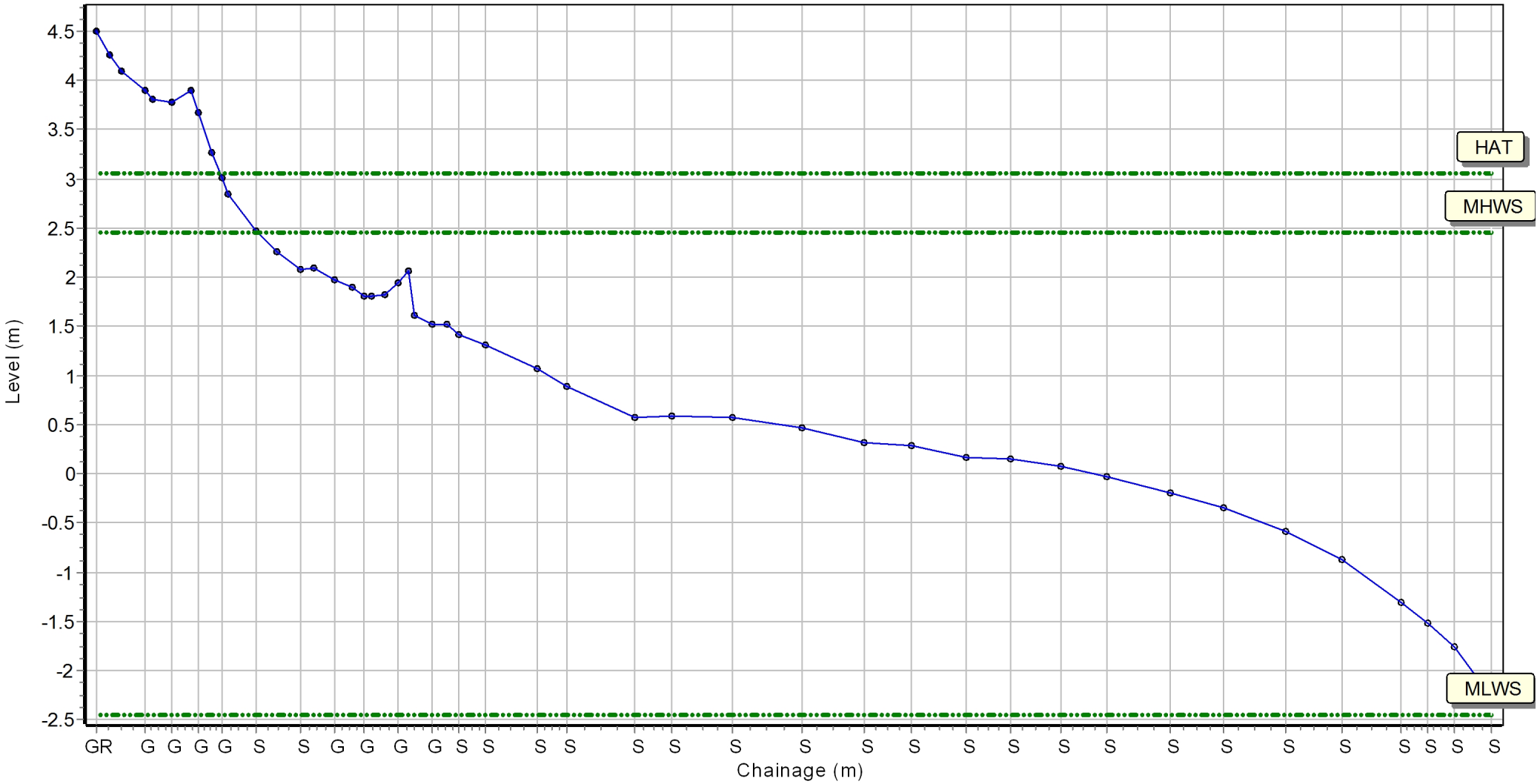
Location: **1dCY1A**

Date: 19/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 506298.519 **Northing:** 485175.932 **Profile Bearing:** 107 from North



Beach Profile

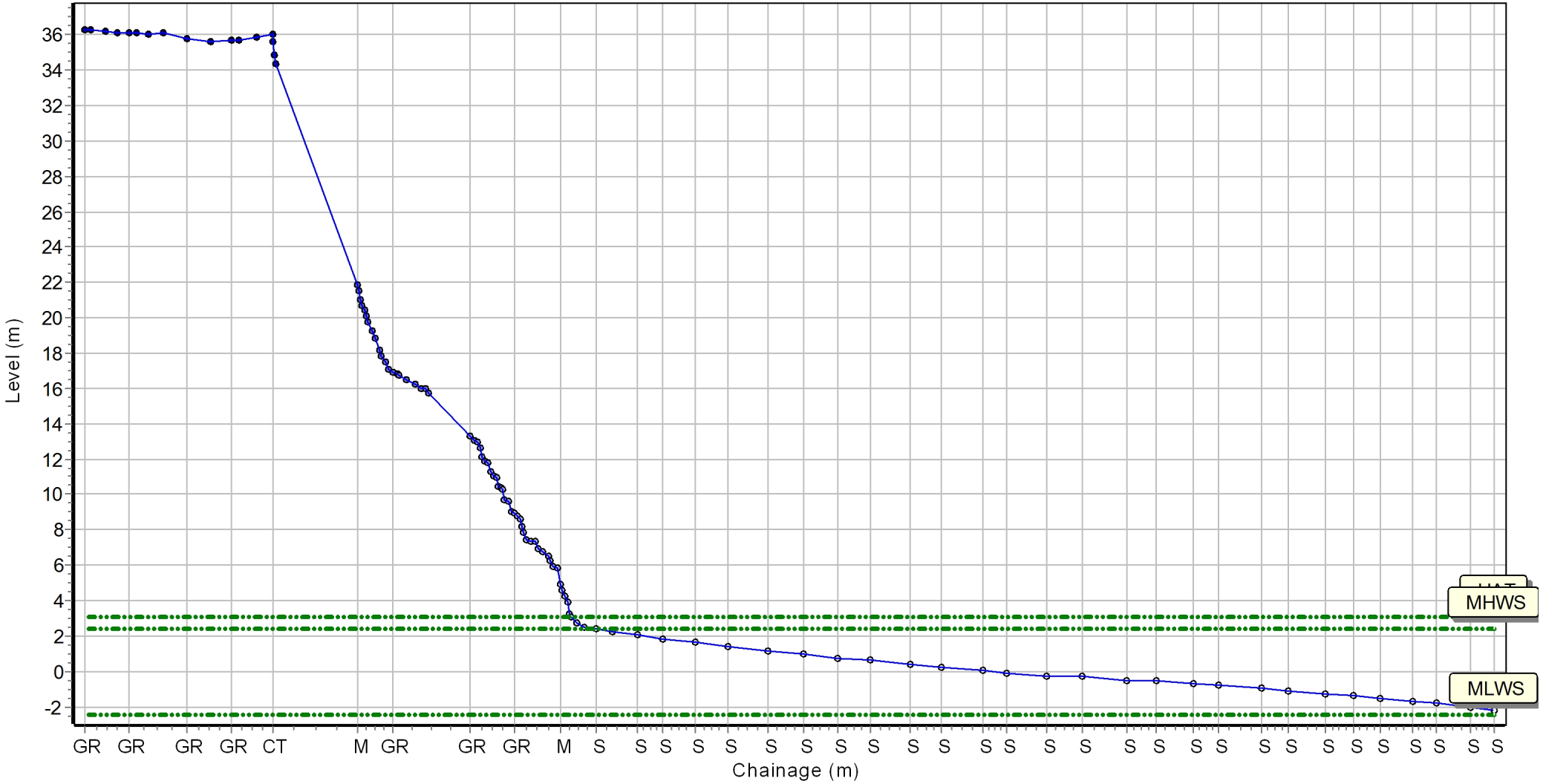
Location: **1dCY2**

Date: 19/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 506712.583 **Northing:** 484325.966 **Profile Bearing:** 38 from North



Beach Profile

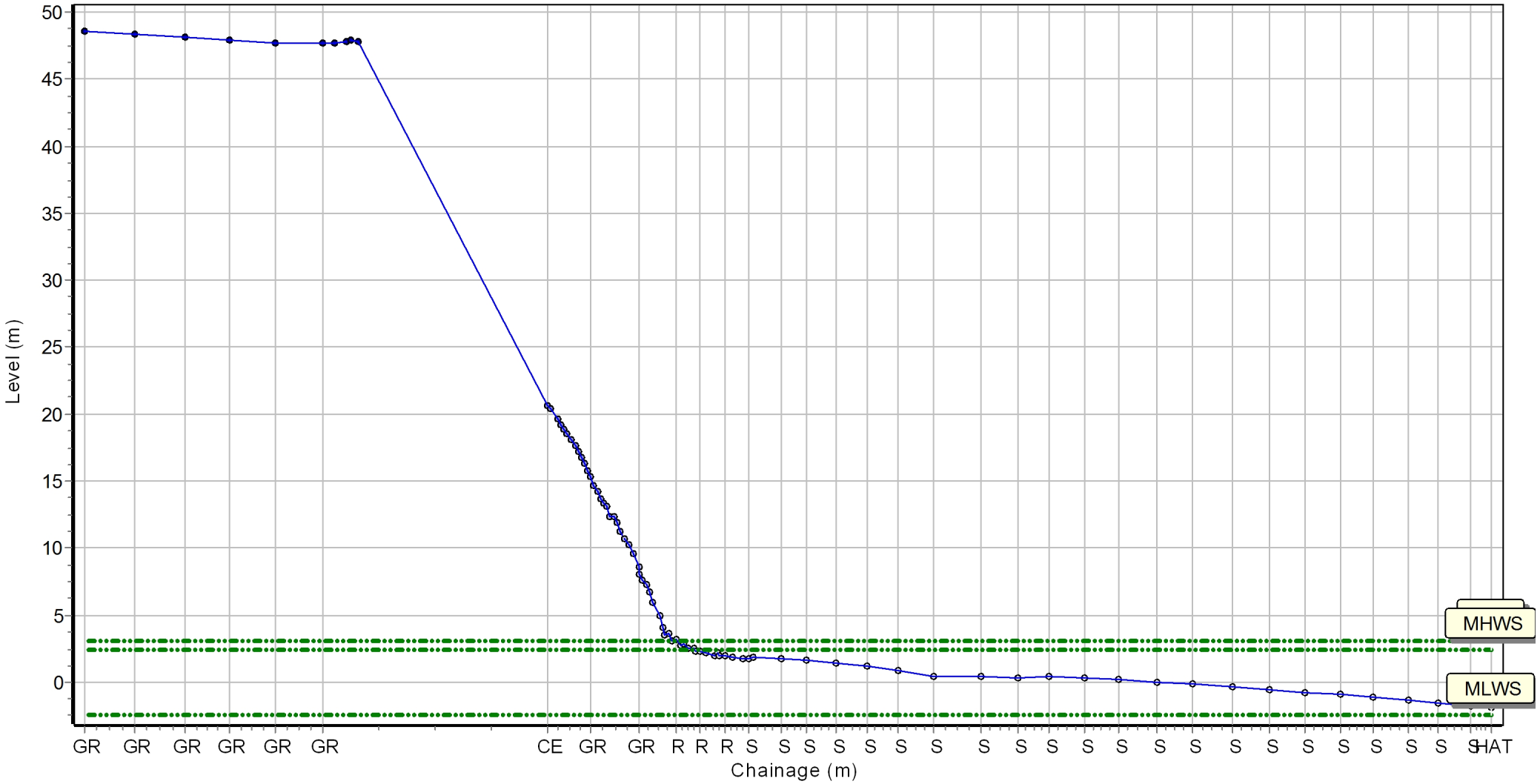
Location: **1dCY3**

Date: 19/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 507242.203 **Northing:** 484080.896 **Profile Bearing:** 42 from North



Beach Profile

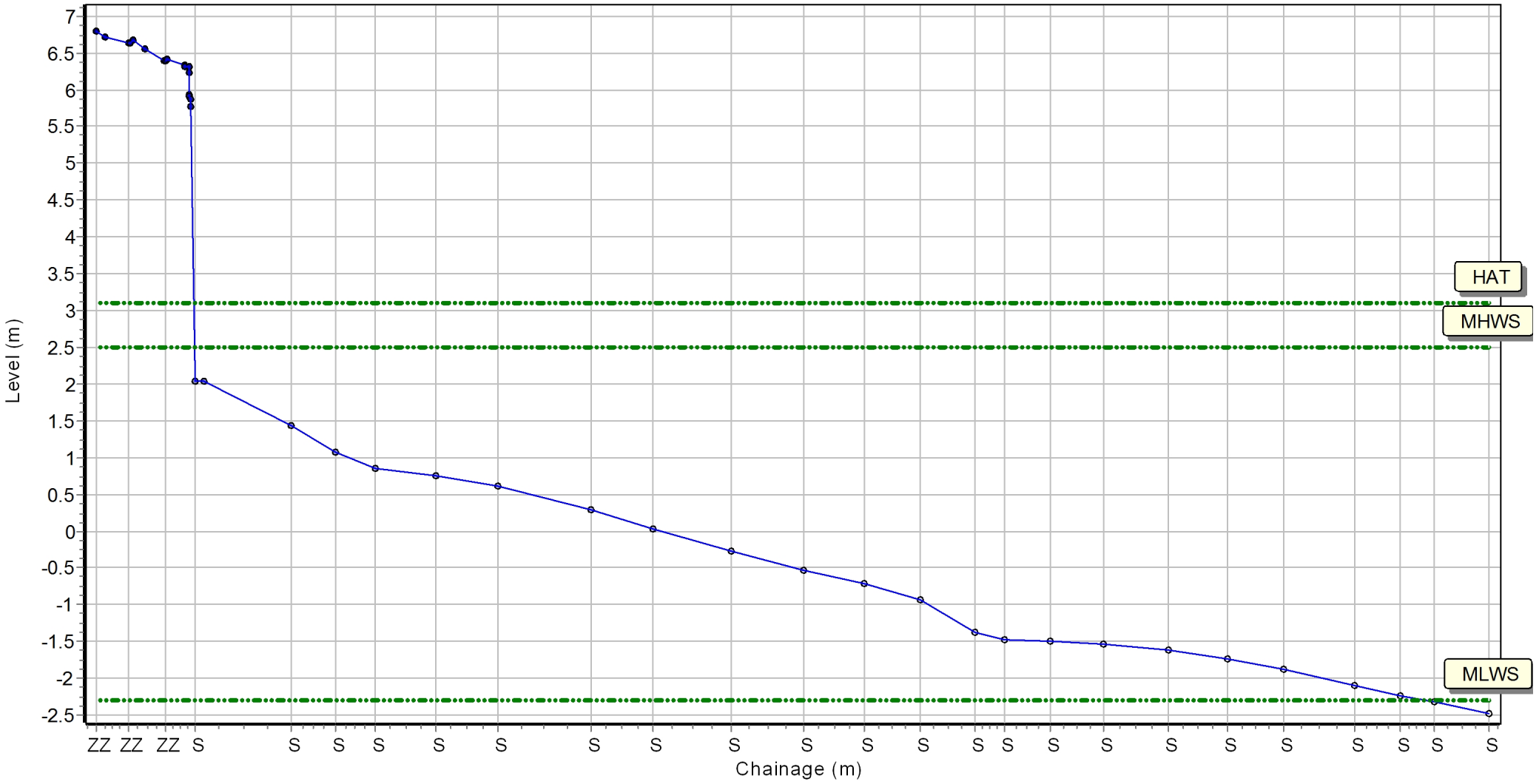
Location: **1dFB1**

Date: 22/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 511989.528 **Northing:** 480590.964 **Profile Bearing:** 100 from North



Beach Profile

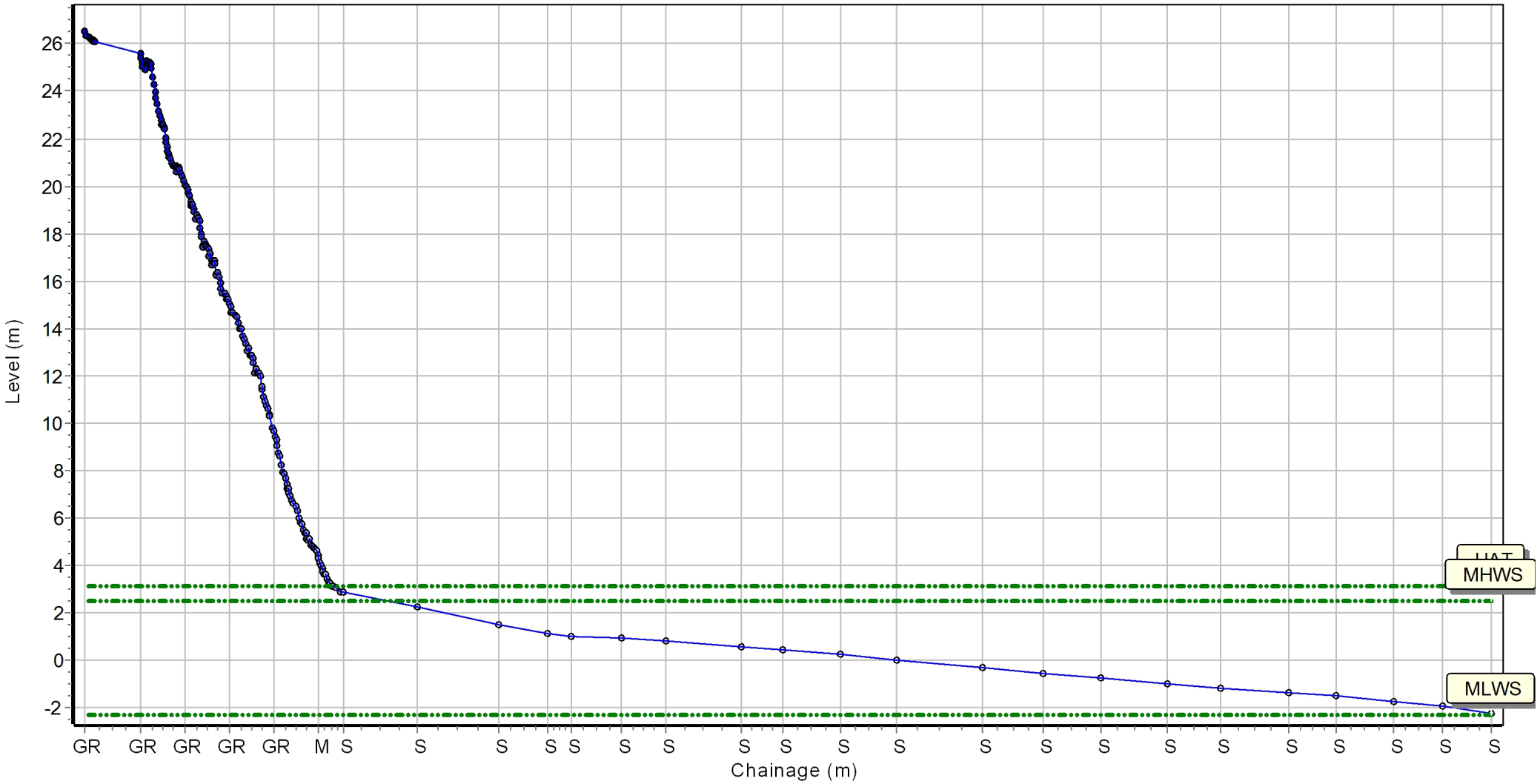
Location: **1dFB2**

Date: 22/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 512005.564 **Northing:** 479181.575 **Profile Bearing:** 77 from North



Beach Profile

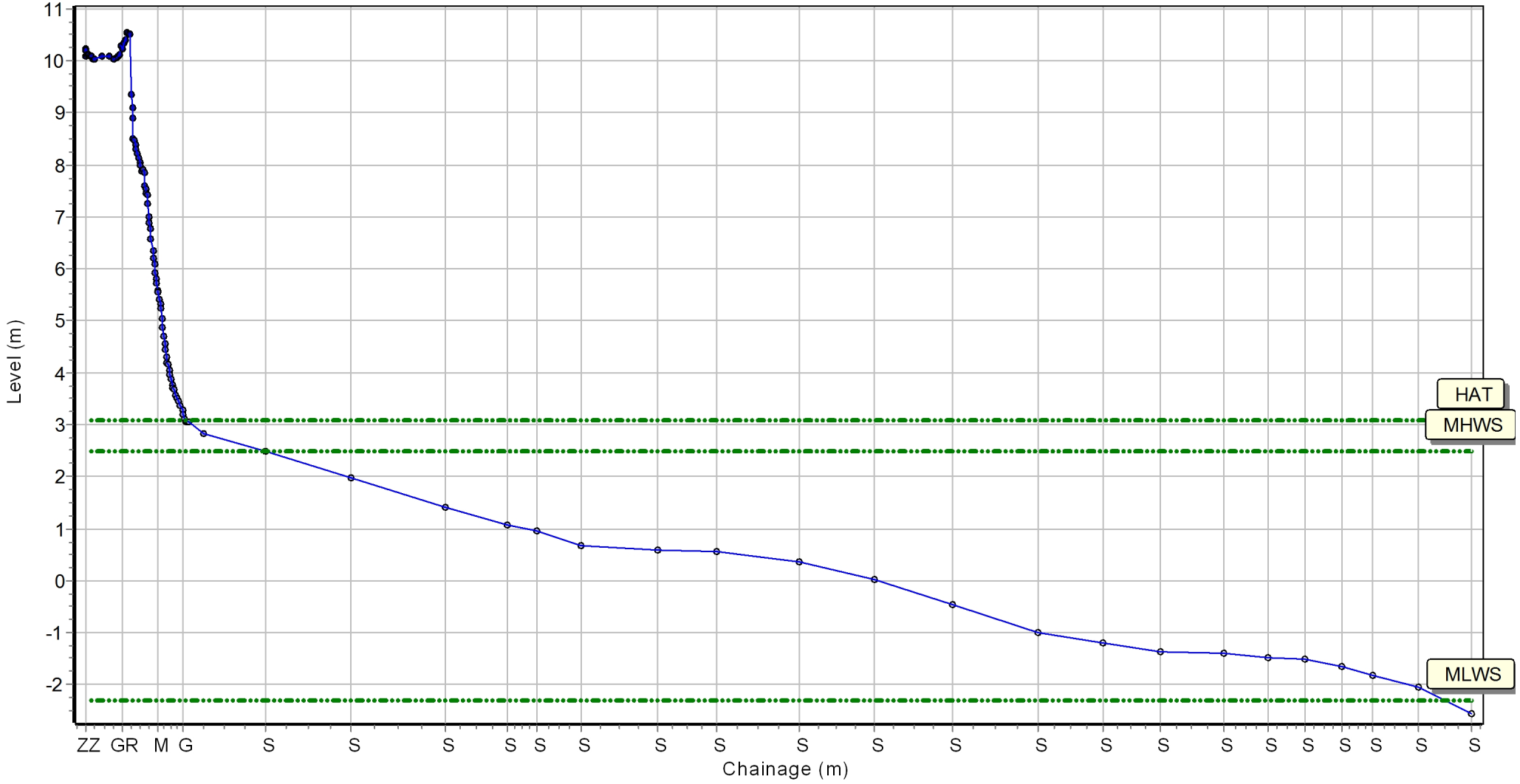
Location: **1dFB3**

Date: 22/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 512429.303 **Northing:** 478202.148 **Profile Bearing:** 61 from North



Beach Profile

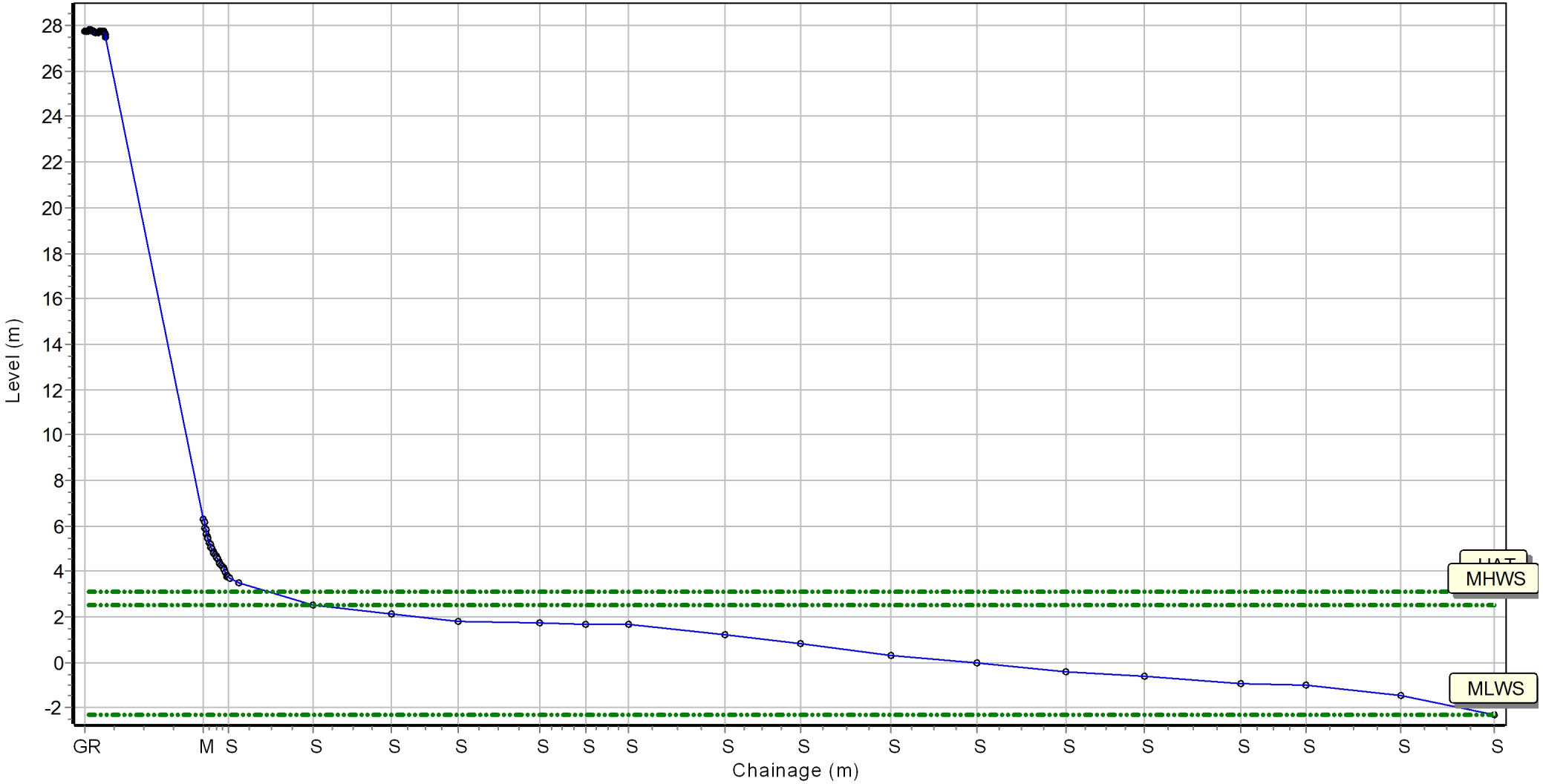
Location: **1dFB4**

Date: 22/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 513165.53 **Northing:** 477182.418 **Profile Bearing:** 51 from North



Beach Profile

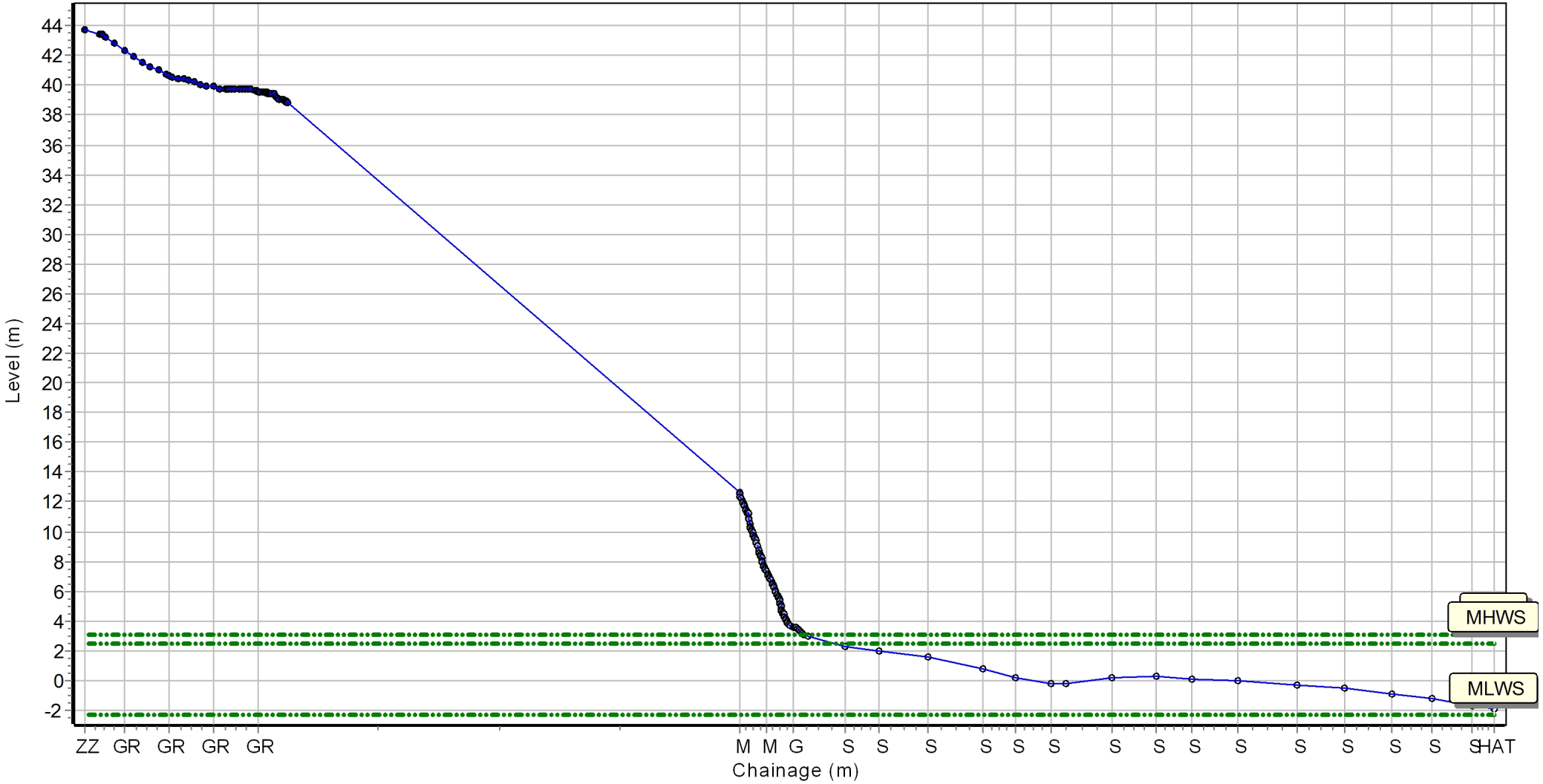
Location: **1dFB5**

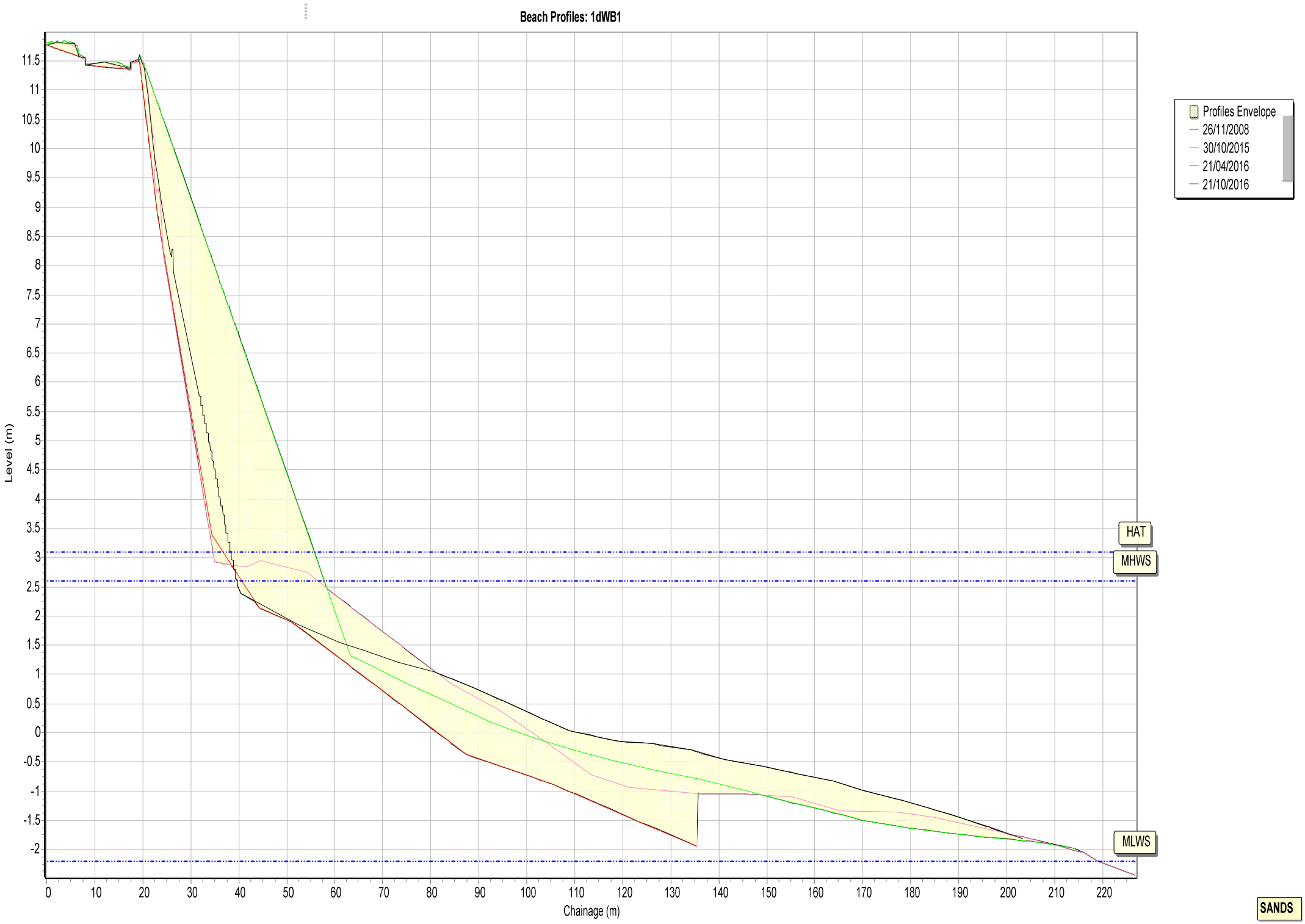
Date: 22/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 514207.792 **Northing:** 476001.334 **Profile Bearing:** 47 from North




Beach Profiles: 1dWB1
Profiles Envelope
26/11/2008
30/10/2015
21/04/2016
21/10/2016
HAT
MHWS
MLWS
SANDS
Level (m)
Chainage (m)
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
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-2
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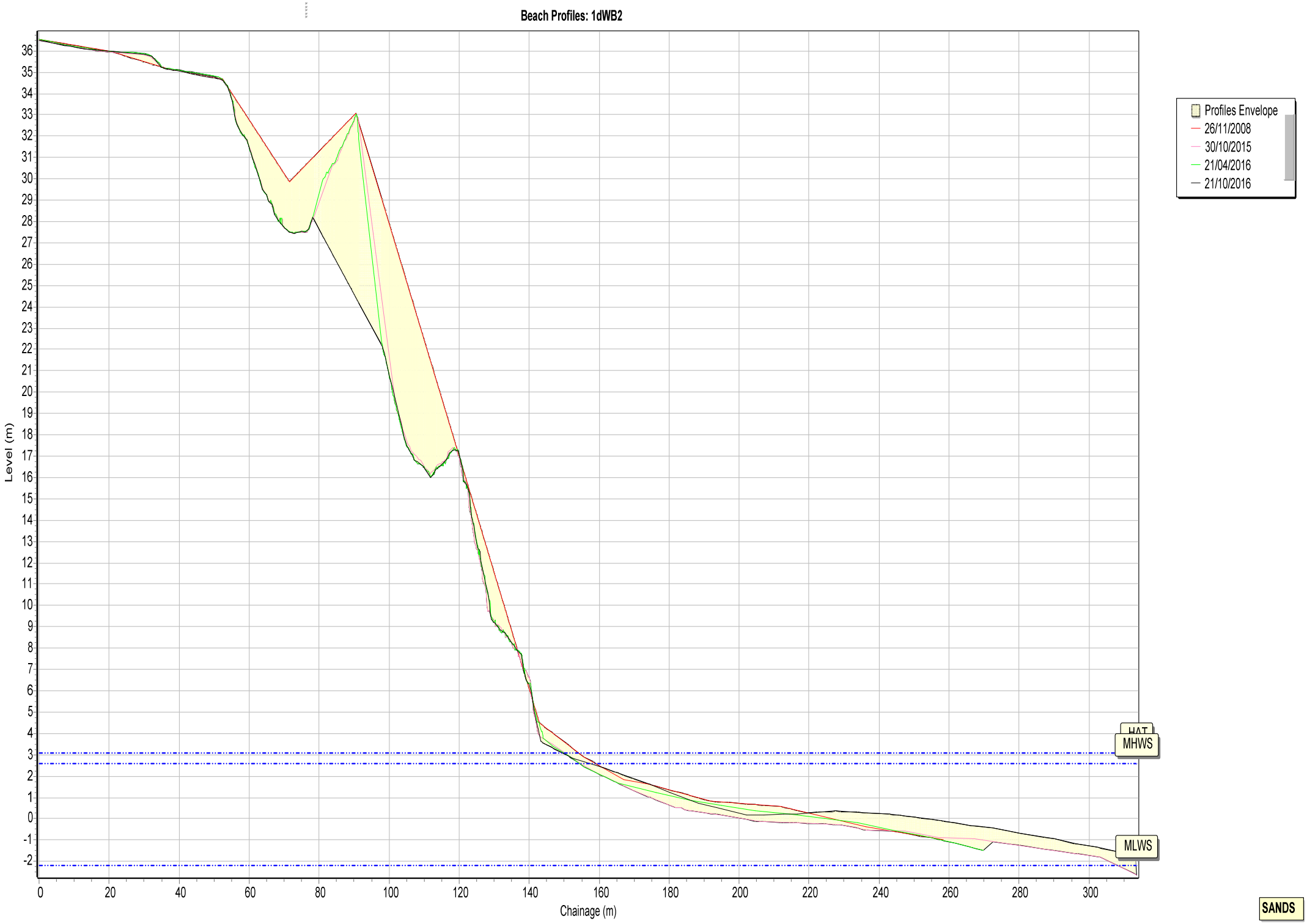
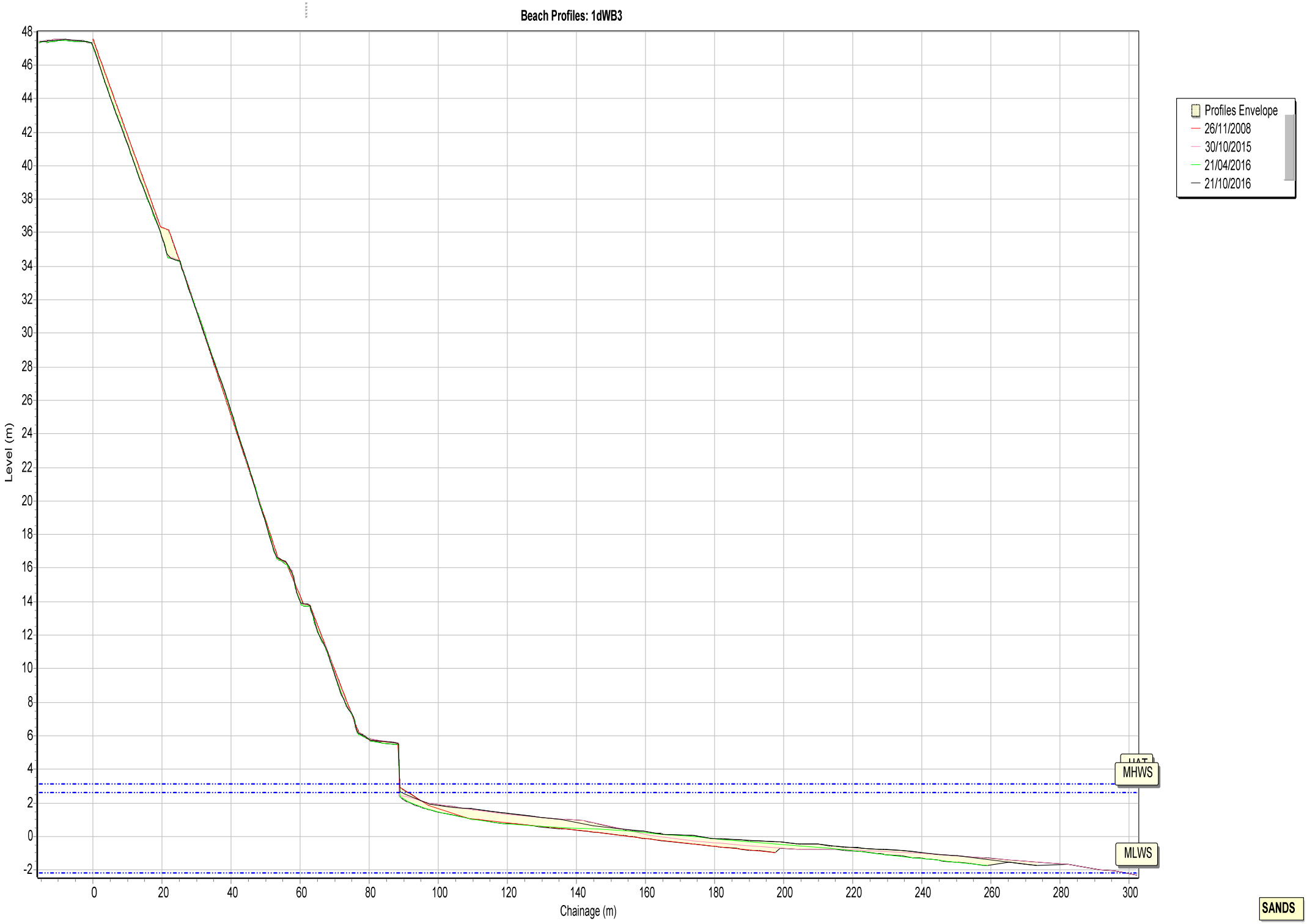
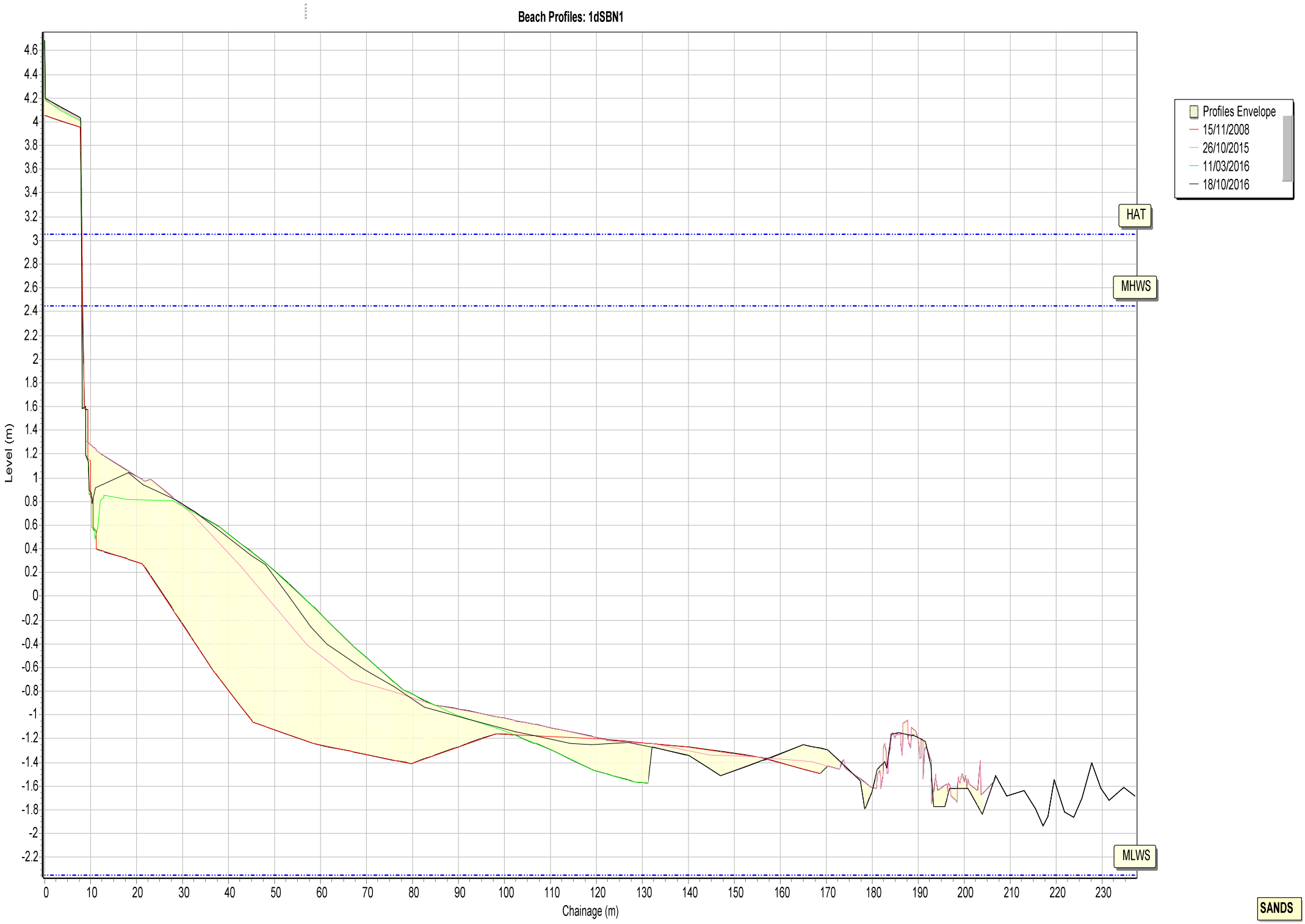

Beach Profiles: 1dWB2
Profiles Envelope
26/11/2008
30/10/2015
21/04/2016
21/10/2016
Level (m)
Chainage (m)
MHWS
MLWS
SANDS


Beach Profiles: 1dWB3
Profiles Envelope
26/11/2008
30/10/2015
21/04/2016
21/10/2016
Level (m)
Chainage (m)
MHWS
MLWS
SANDS


Beach Profiles: 1dSBN1
Profiles Envelope
15/11/2008
26/10/2015
11/03/2016
18/10/2016
HAT
MHWS
MLWS
SANDS
Level (m)
Chainage (m)
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
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-0.4
-0.6
-0.8
-1
-1.2
-1.4
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-2
-2.2
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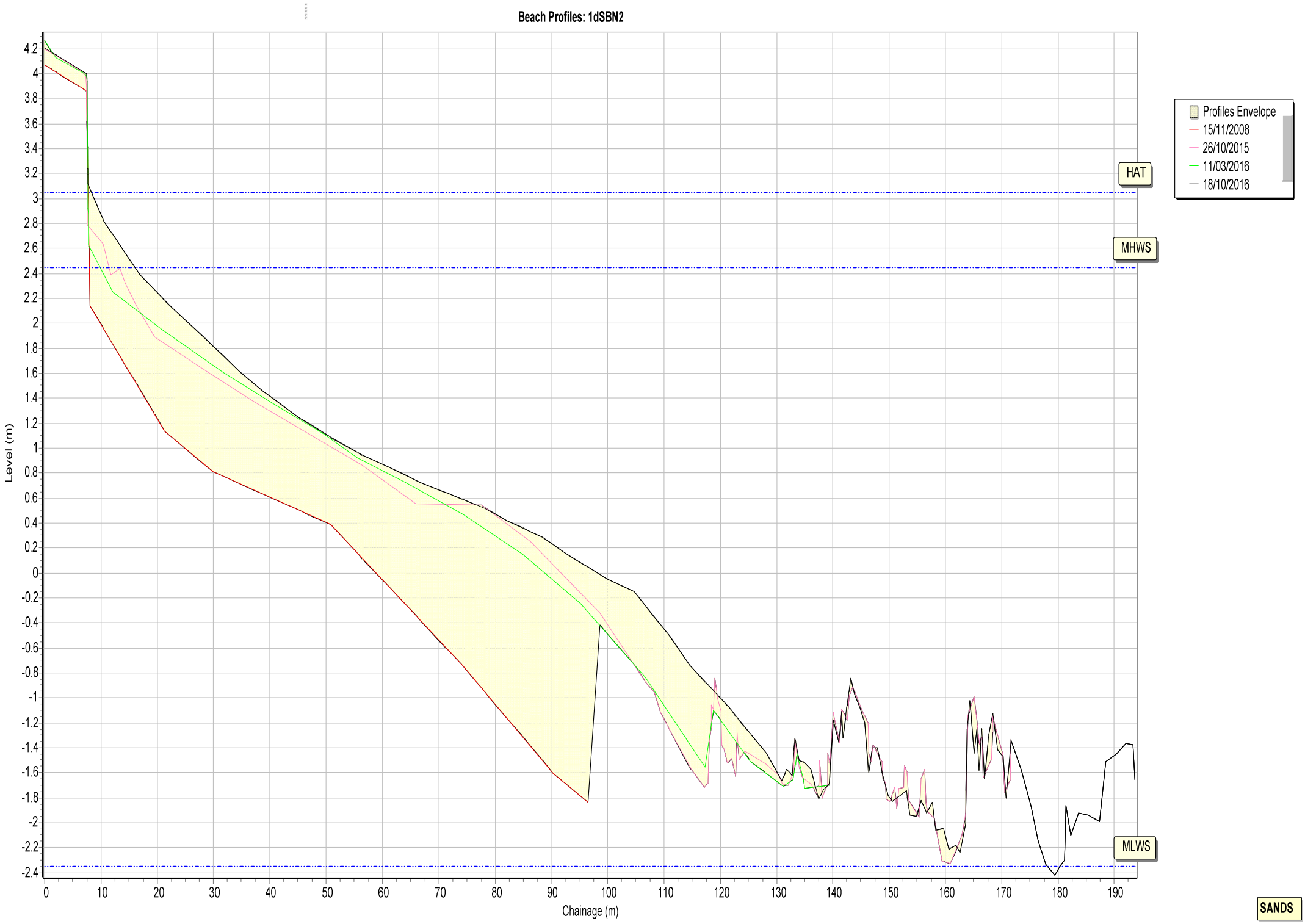
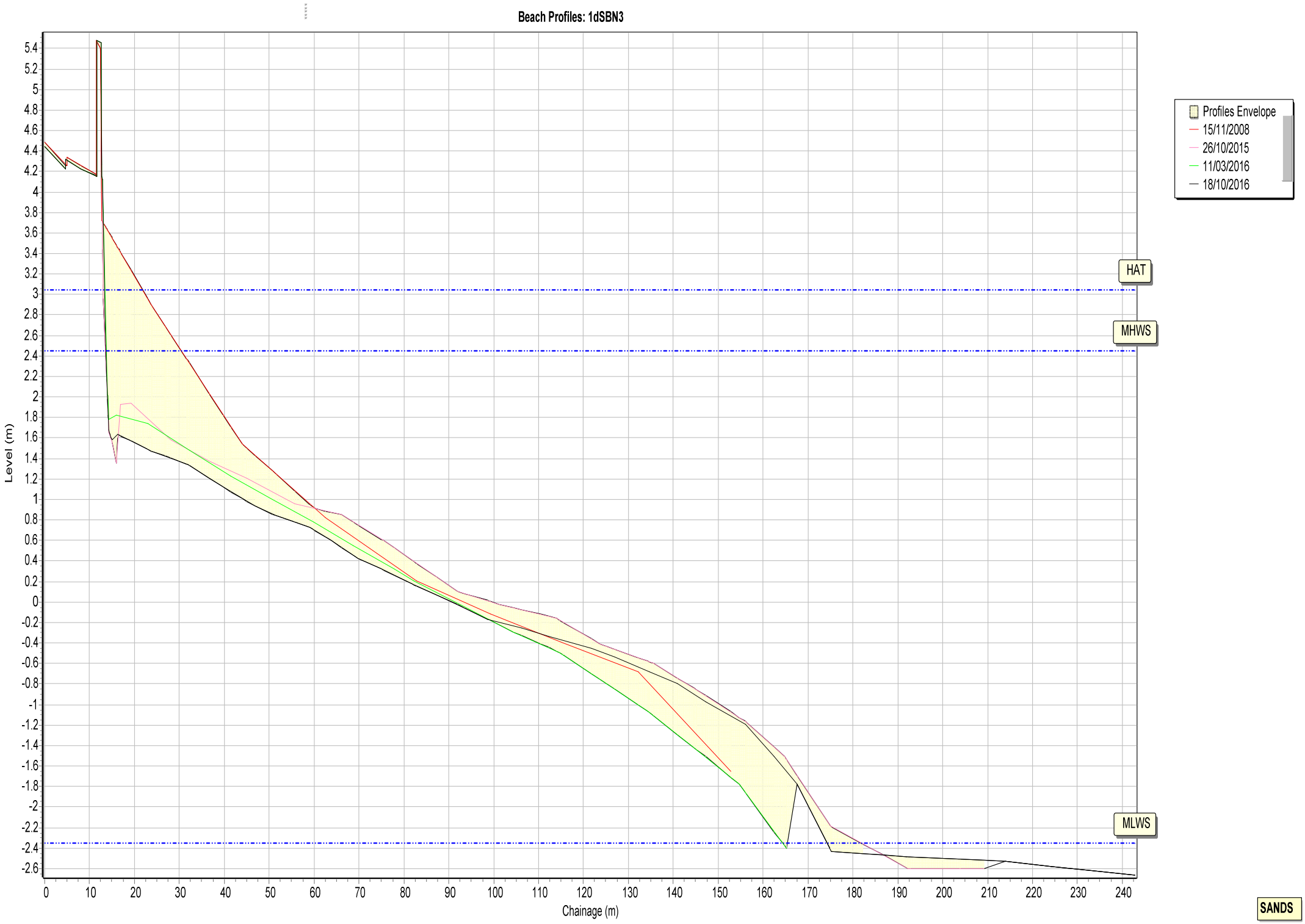

Beach Profiles: 1dSBN2
Profiles Envelope
15/11/2008
26/10/2015
11/03/2016
18/10/2016
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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Profiles Envelope
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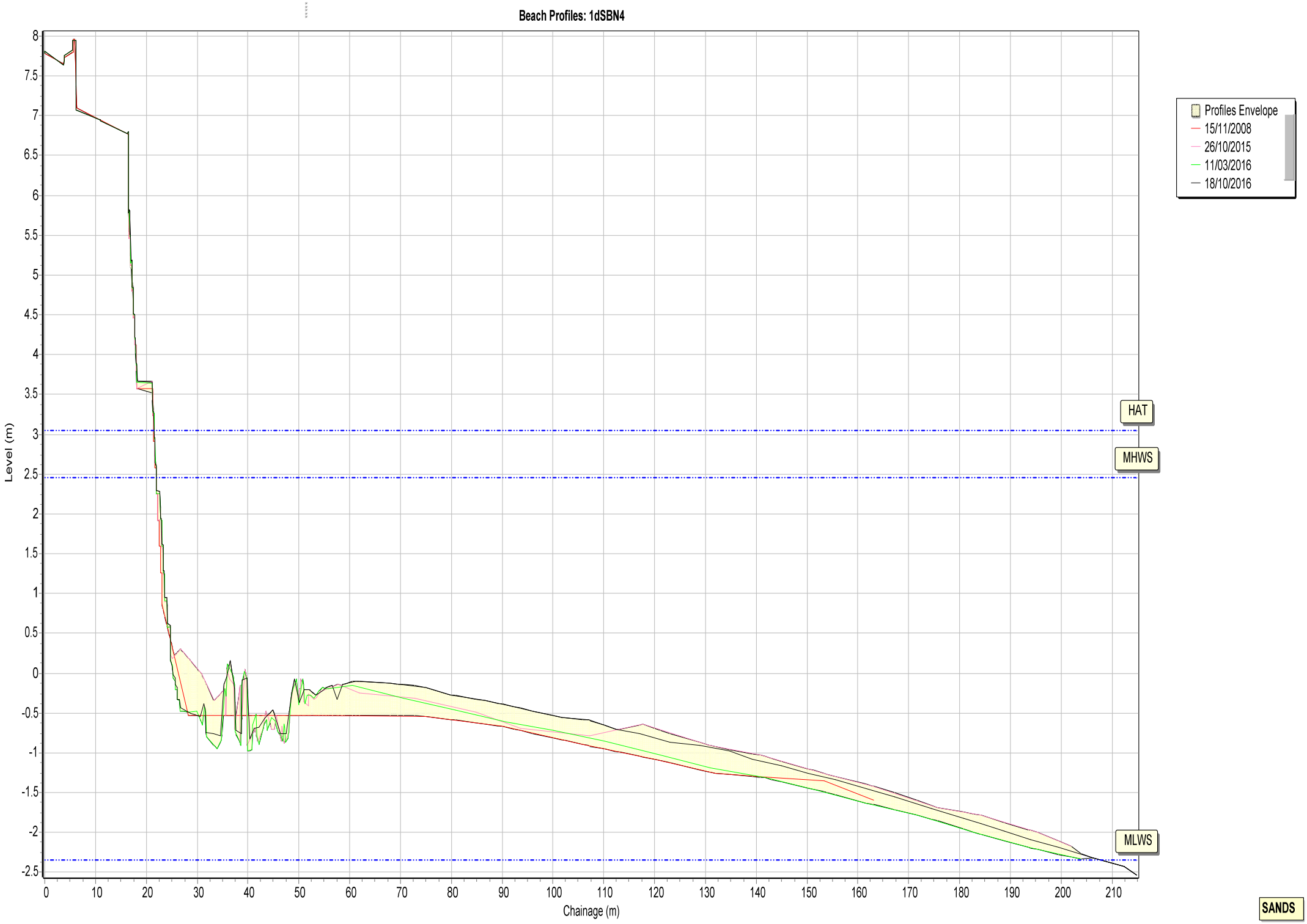
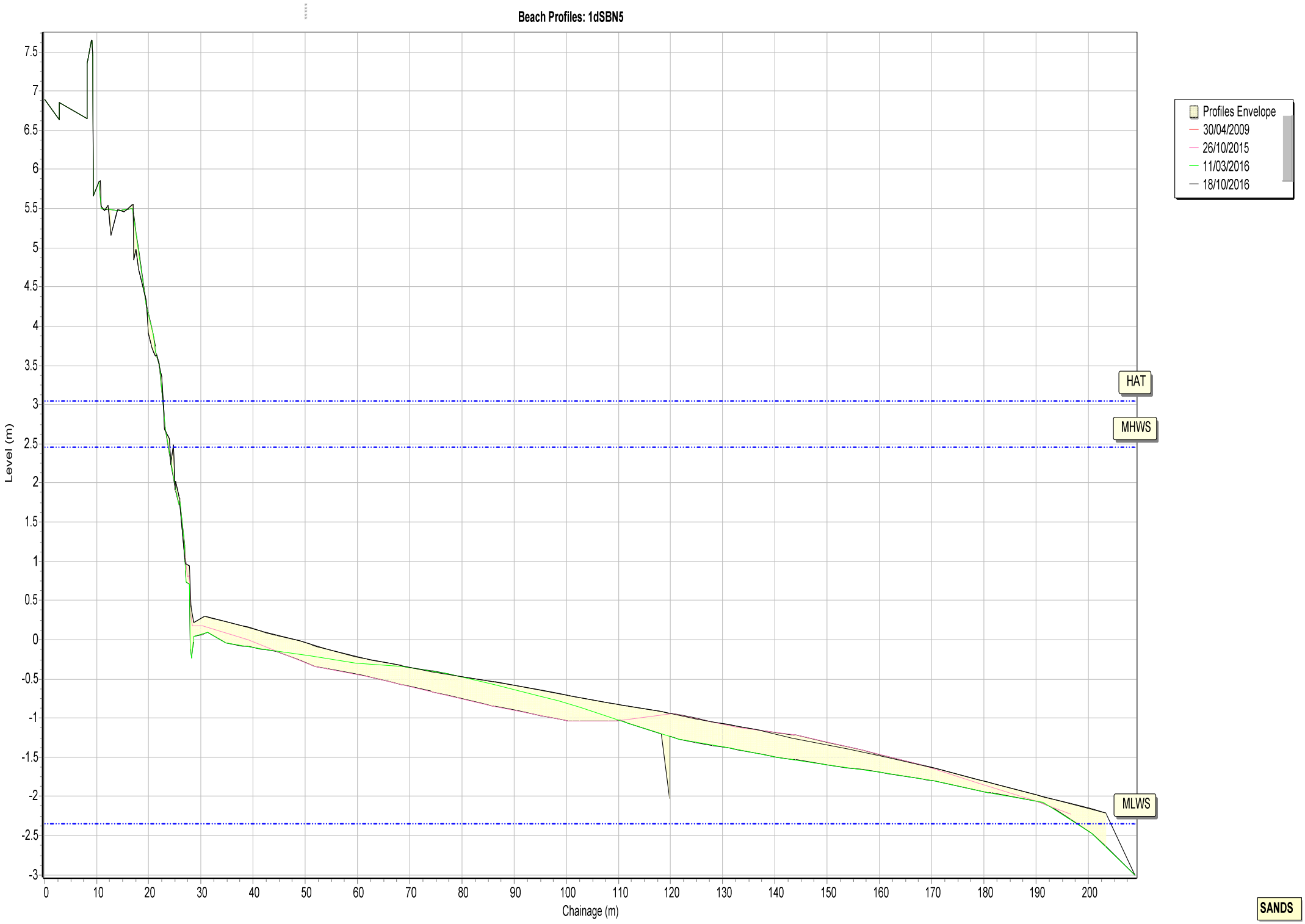
26/10/2015
11/03/2016
18/10/2016
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS


Beach Profiles: 1dSBN4
Profiles Envelope
15/11/2008
26/10/2015
11/03/2016
18/10/2016
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS


Beach Profiles: 1dSBN5
Profiles Envelope
30/04/2009
26/10/2015
11/03/2016
18/10/2016
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

Beach Profile

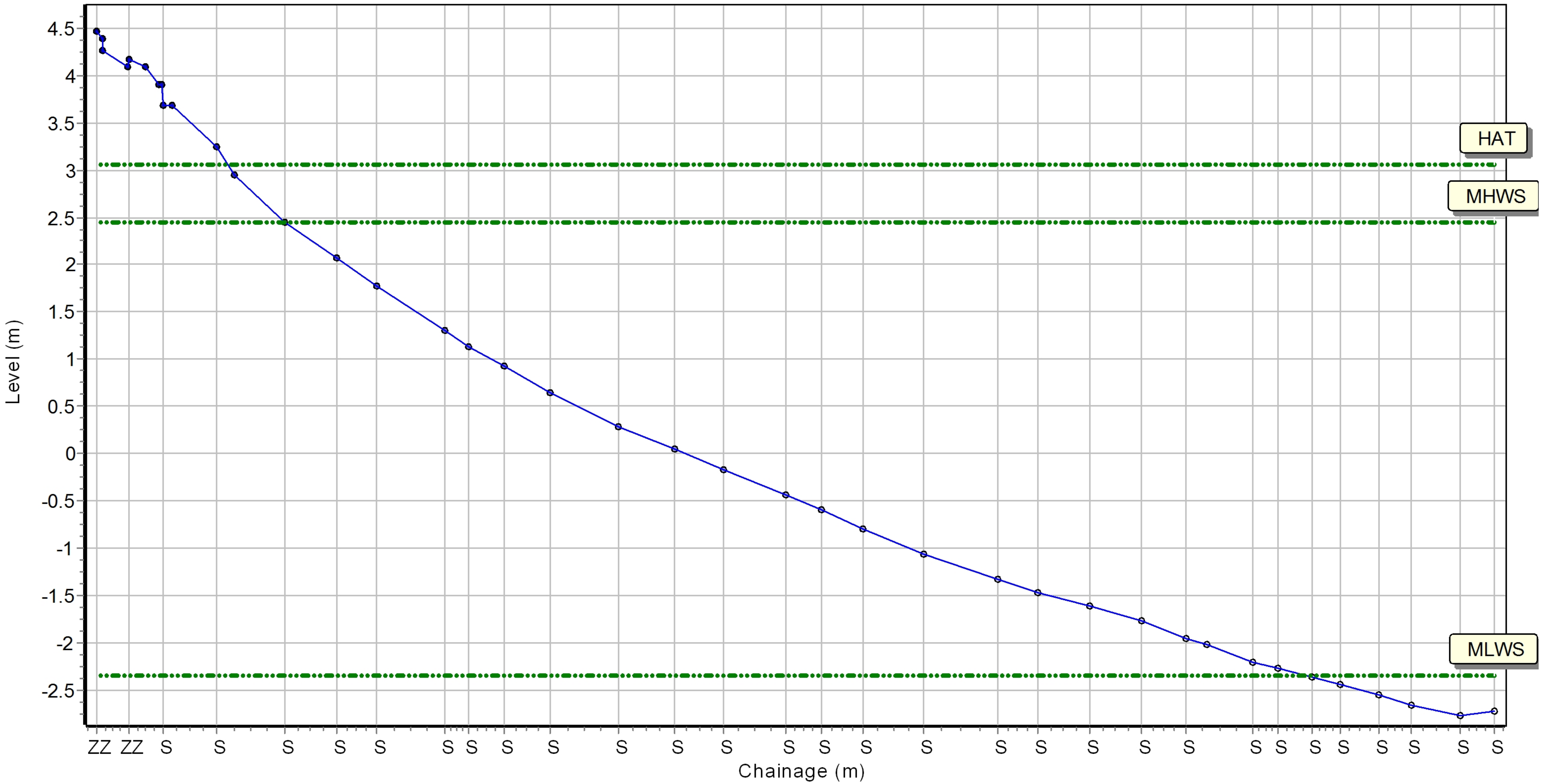
Location: 1dSBS1

Date: 17/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504544.727 **Northing:** 488604.814 **Profile Bearing:** 120 from North



Beach Profile

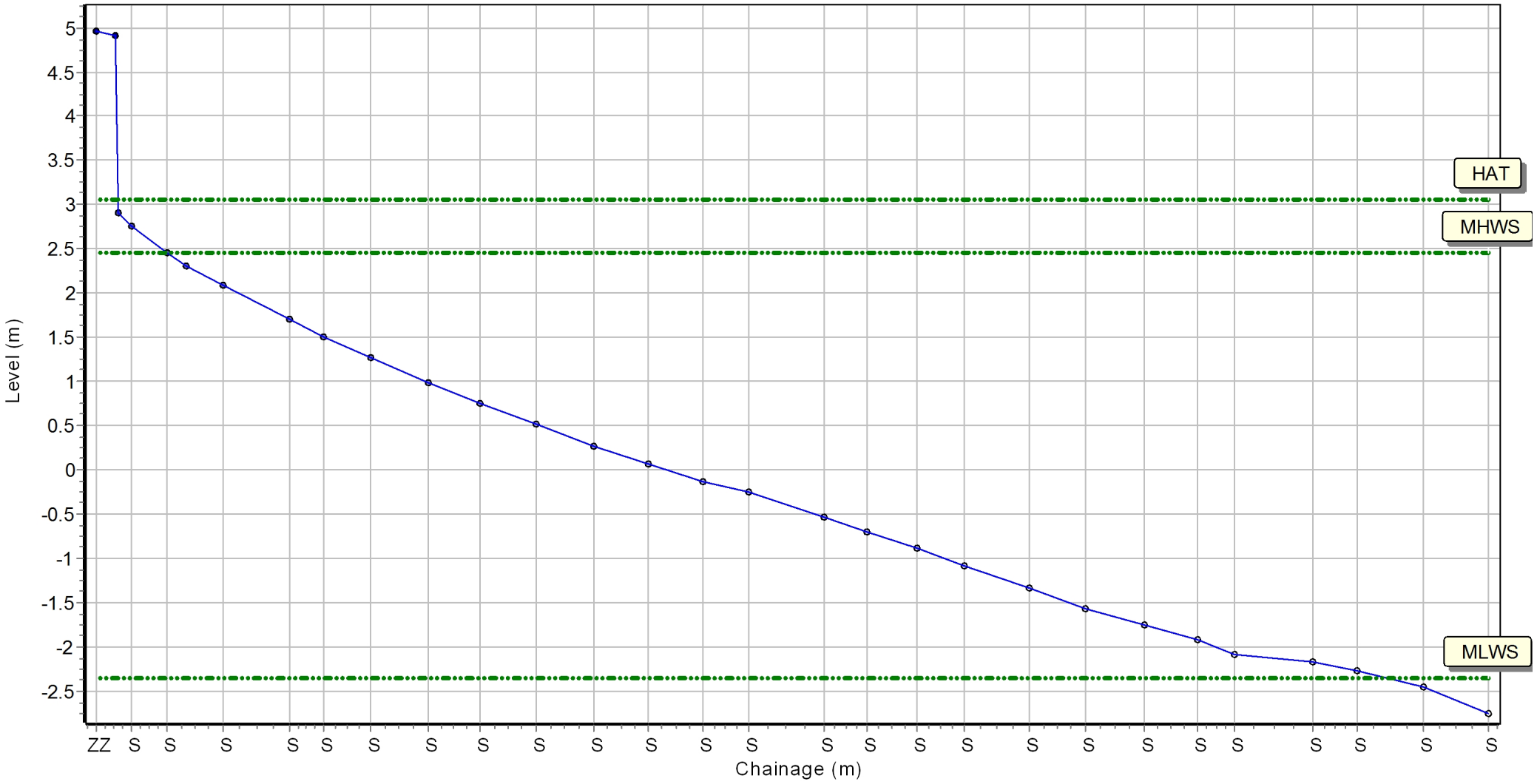
Location: **1dSBS2**

Date: 17/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504443.218 **Northing:** 488326.371 **Profile Bearing:** 105 from North



Beach Profile

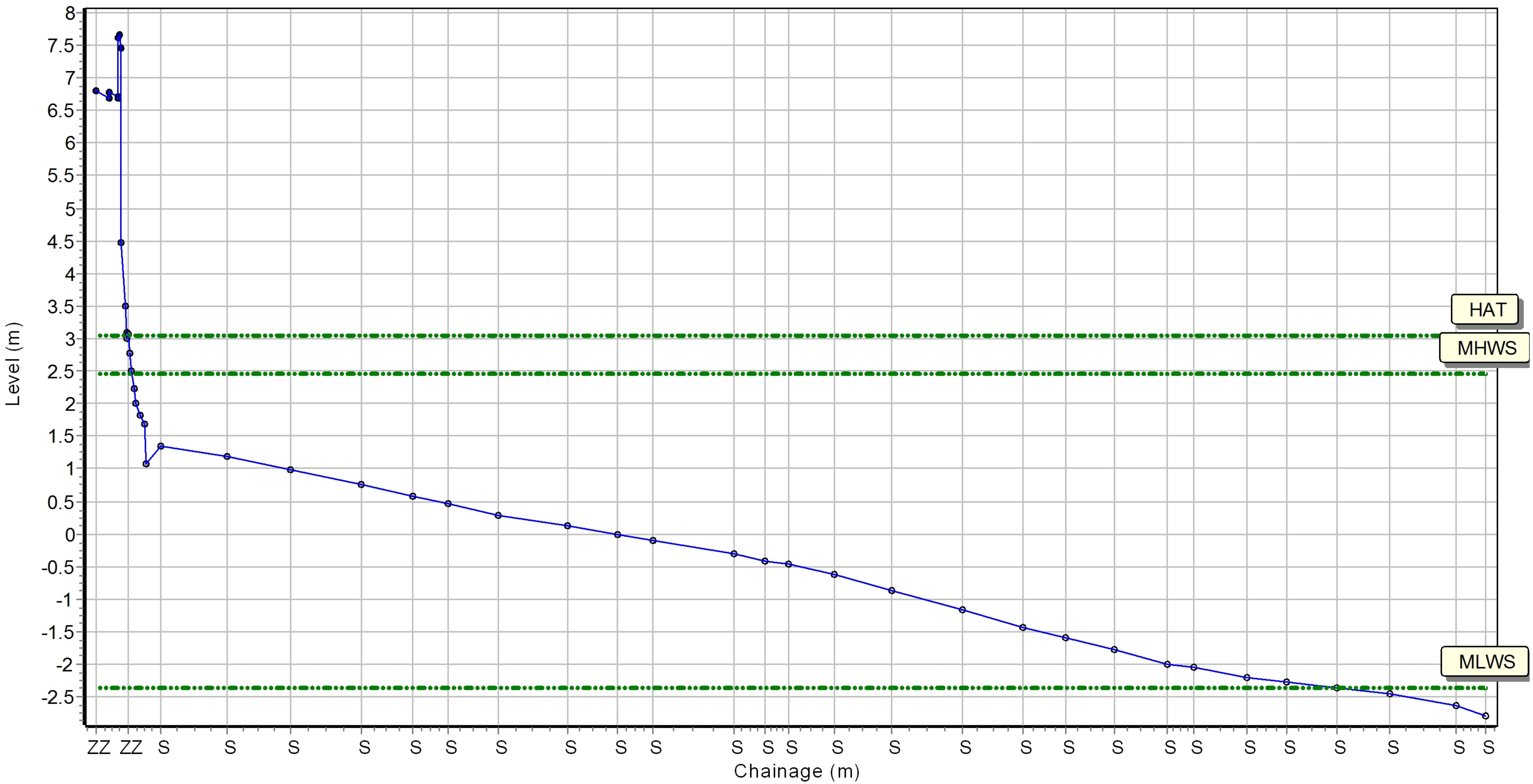
Location: 1dSBS3

Date: 17/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504423.086 **Northing:** 488057.66 **Profile Bearing:** 83 from North



Beach Profile

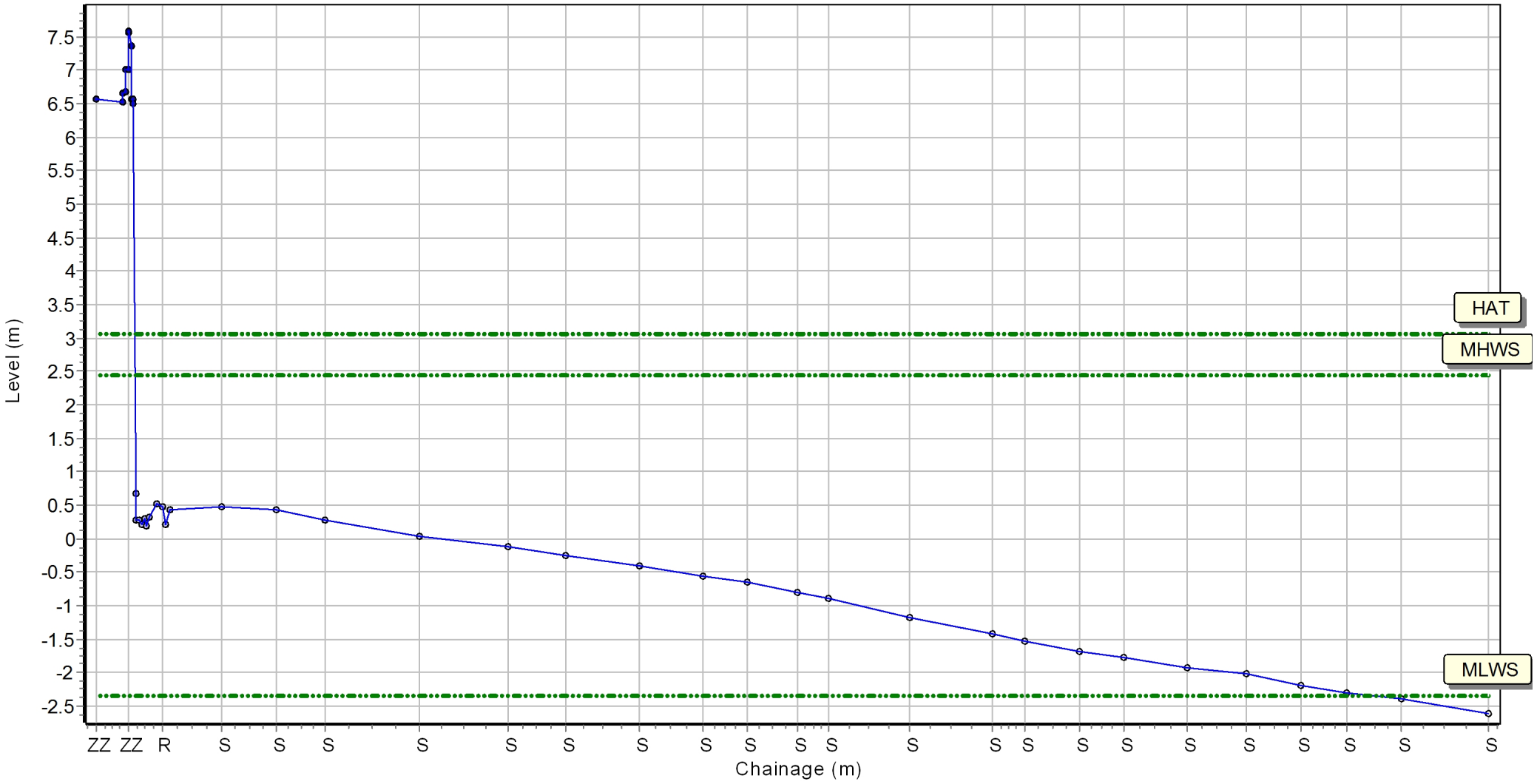
Location: **1dSBS4**

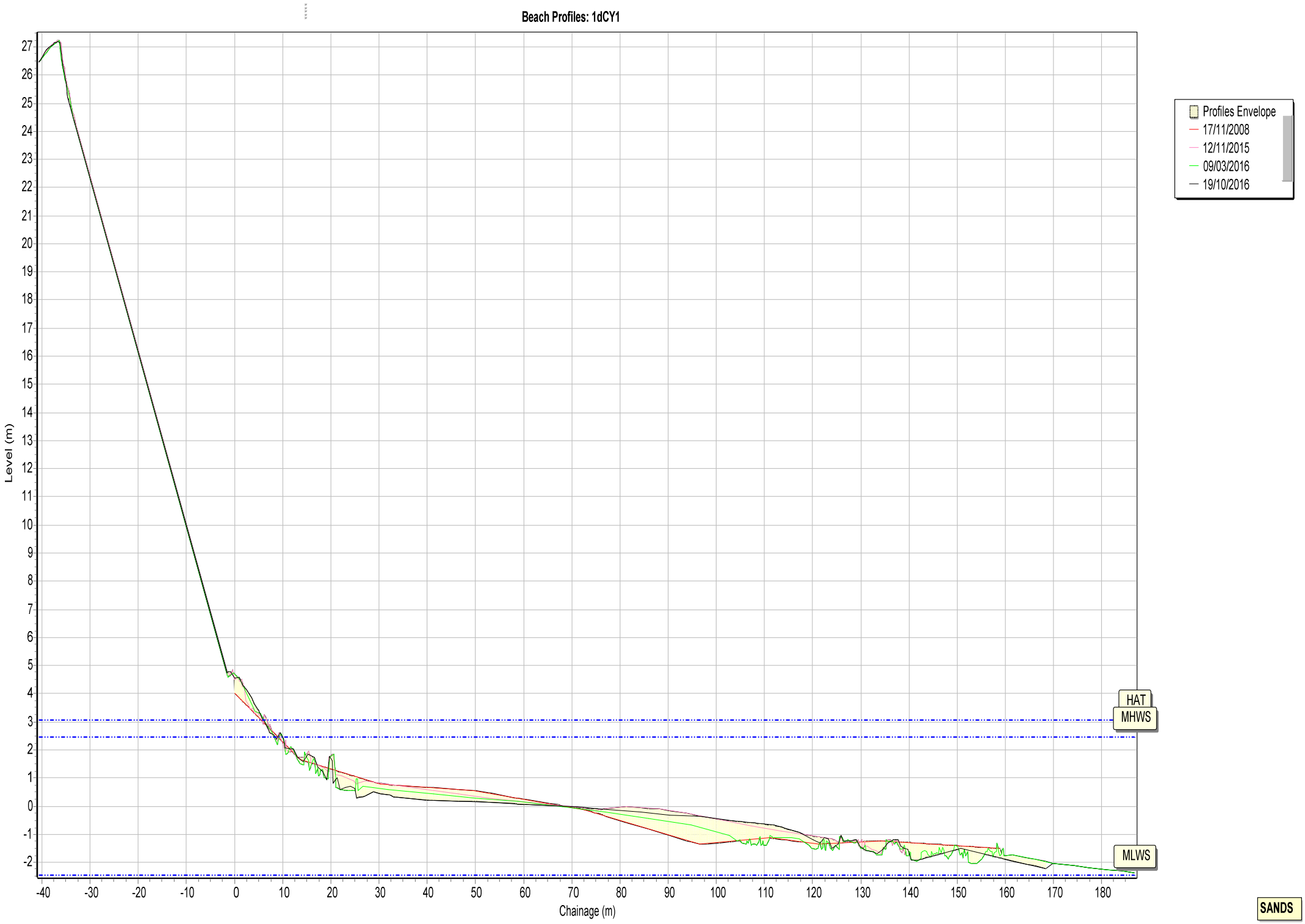
Date: 17/10/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

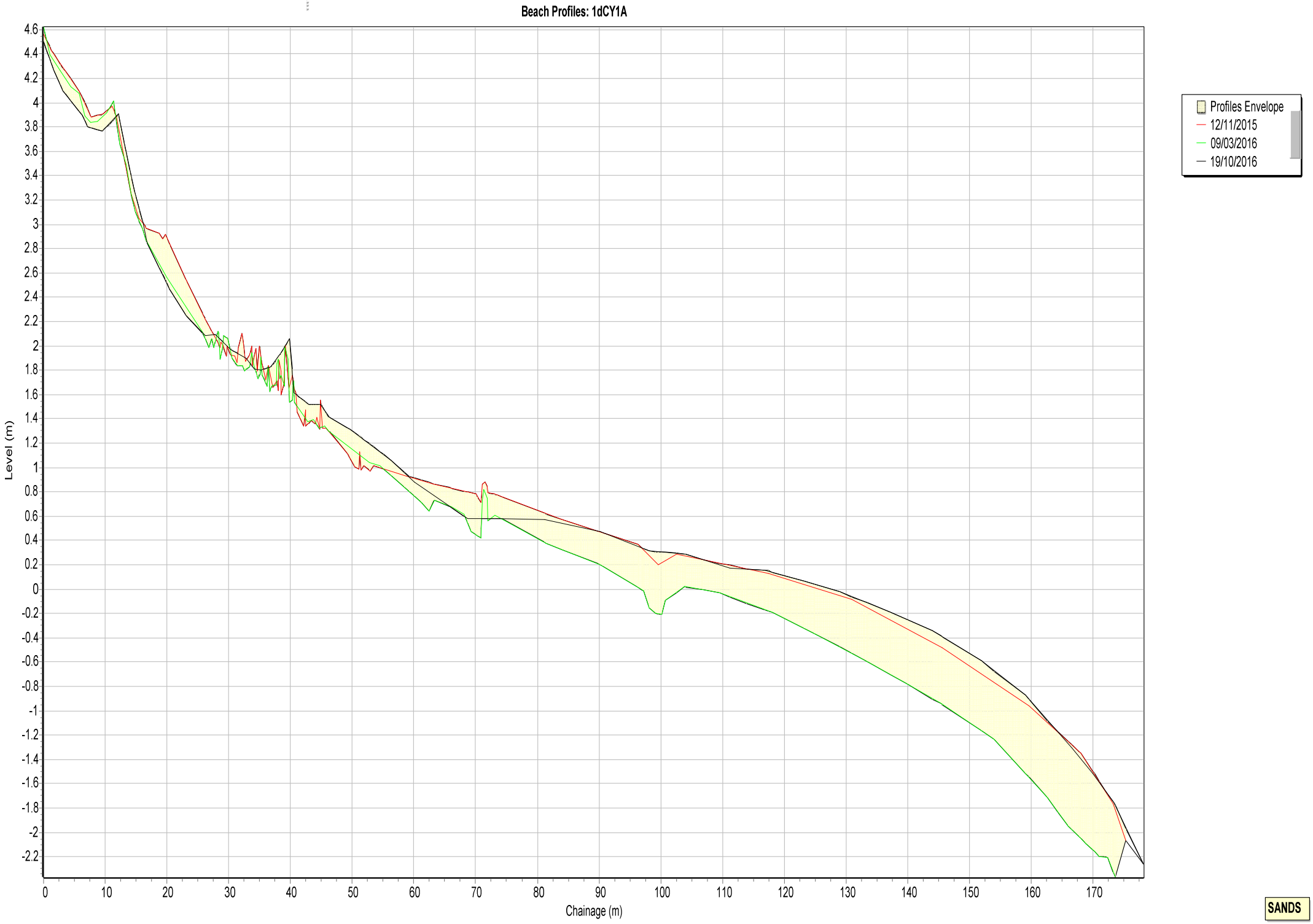
Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 504494.785 **Northing:** 487816.983 **Profile Bearing:** 74 from North




Beach Profiles: 1dCY1
Profiles Envelope
17/11/2008
12/11/2015
09/03/2016
19/10/2016
Level (m)
Chainage (m)
HAT
MHWS
MLWS
SANDS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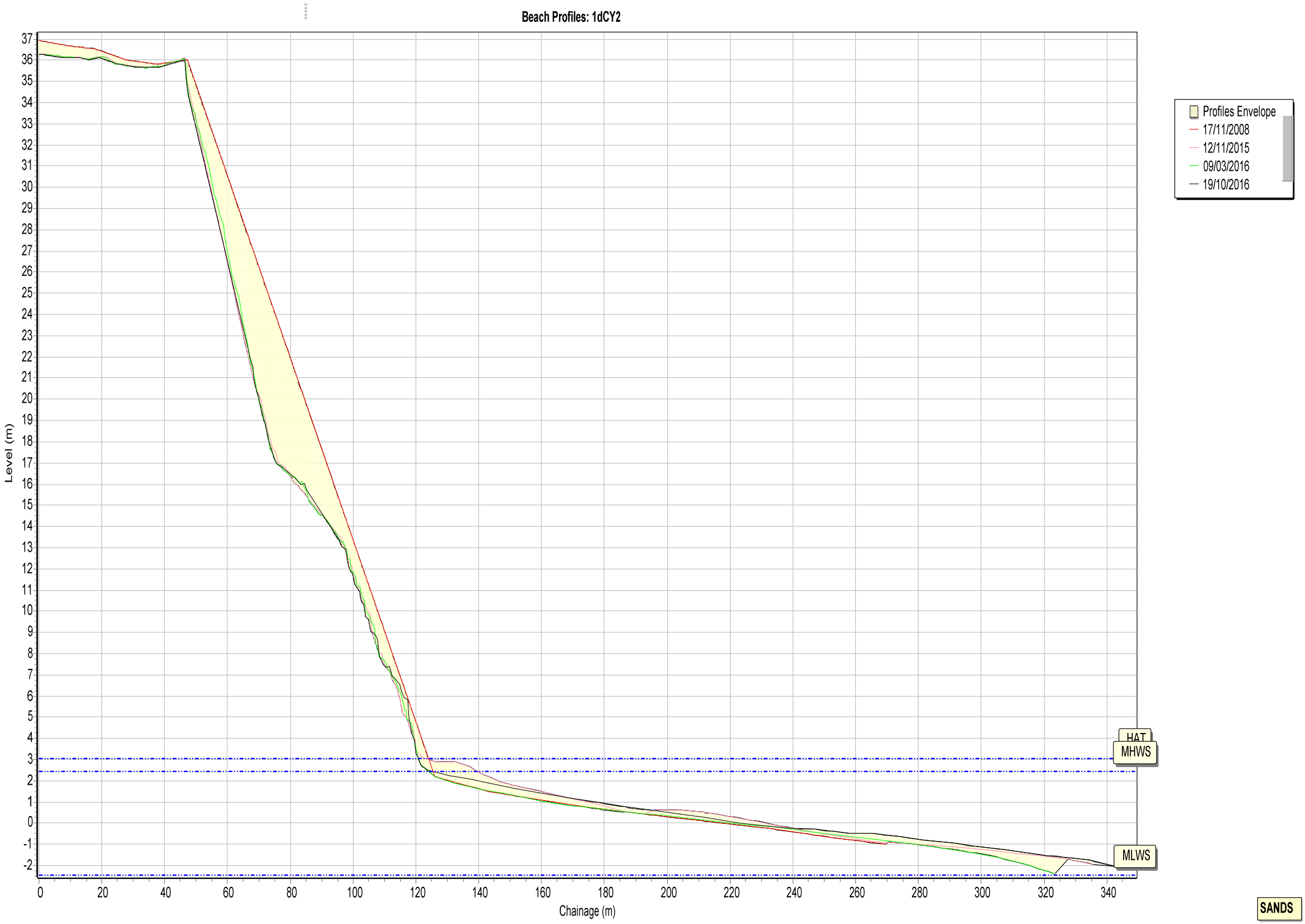
09/03/2016
19/10/2016
Level (m)
Chainage (m)
SANDS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Profiles Envelope
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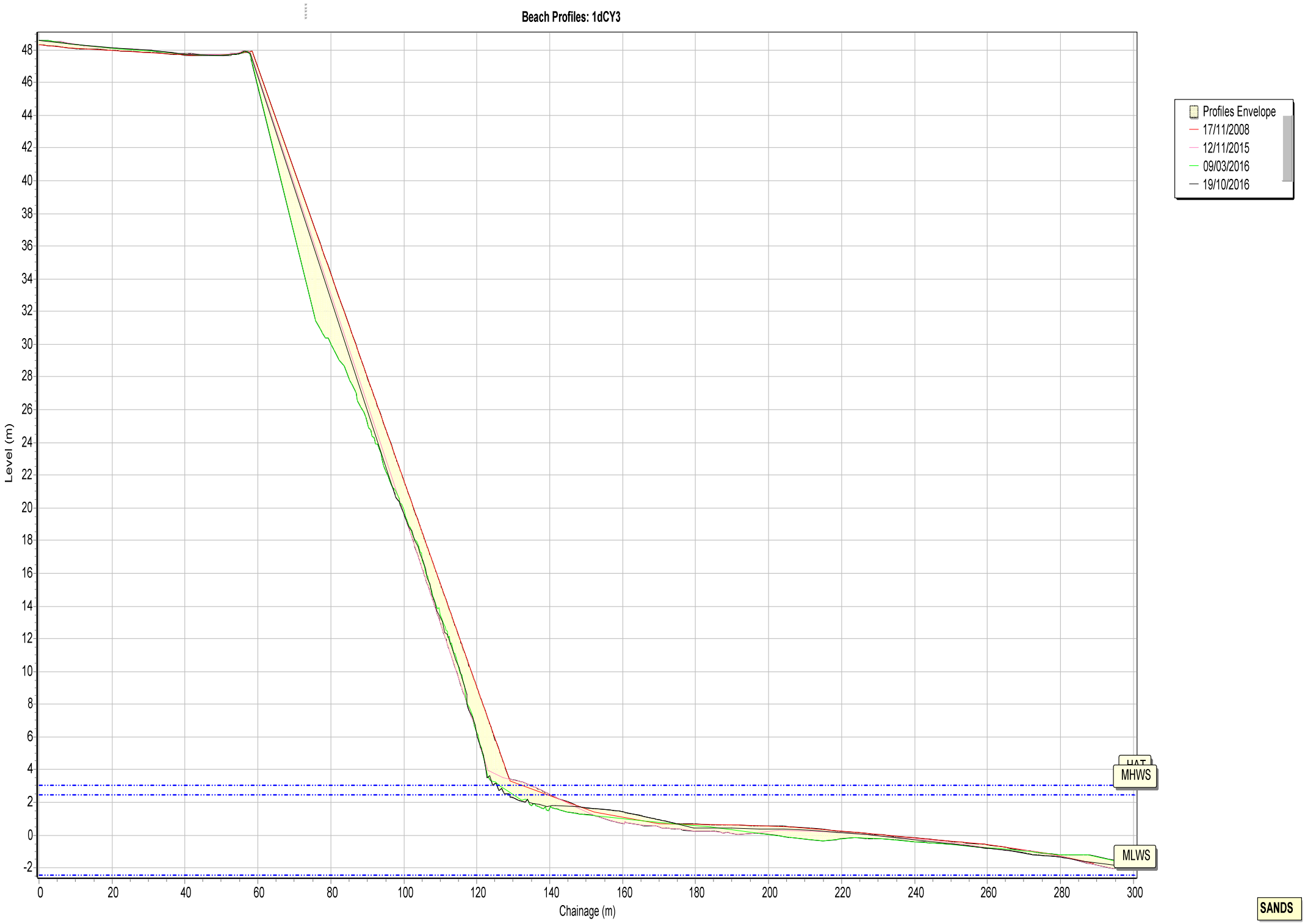
09/03/2016
19/10/2016
Level (m)
Chainage (m)
HAT
MHWS
MLWS
SANDS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Profiles Envelope
17/11/2008
12/11/2015
09/03/2016
19/10/2016
Level (m)
Chainage (m)
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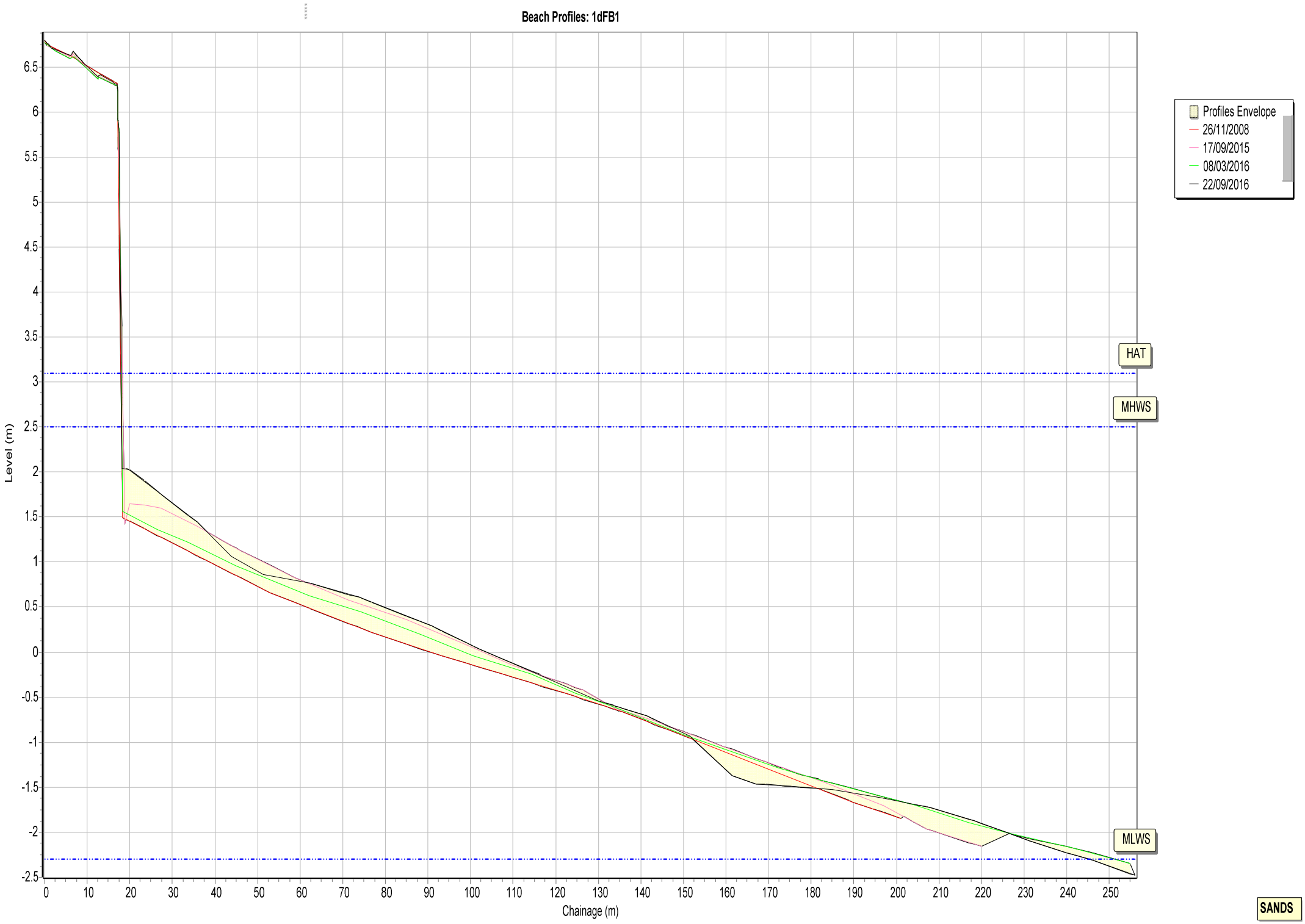
MLWS
SANDS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26/11/2008
17/09/2015
08/03/2016
22/09/2016
HAT
MHWS
MLWS
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6.5
6
5.5
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4.5
4
3.5
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2.5
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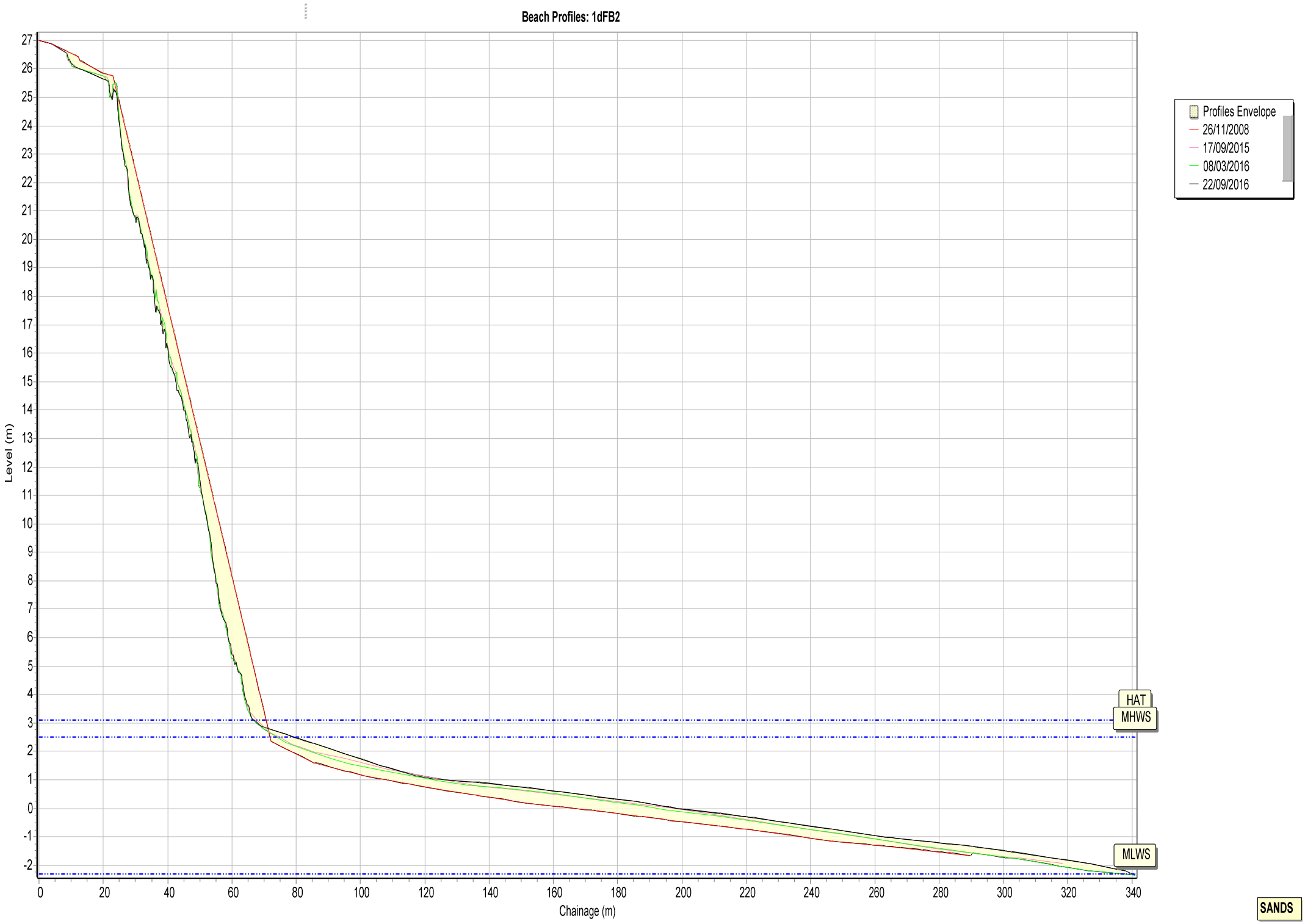
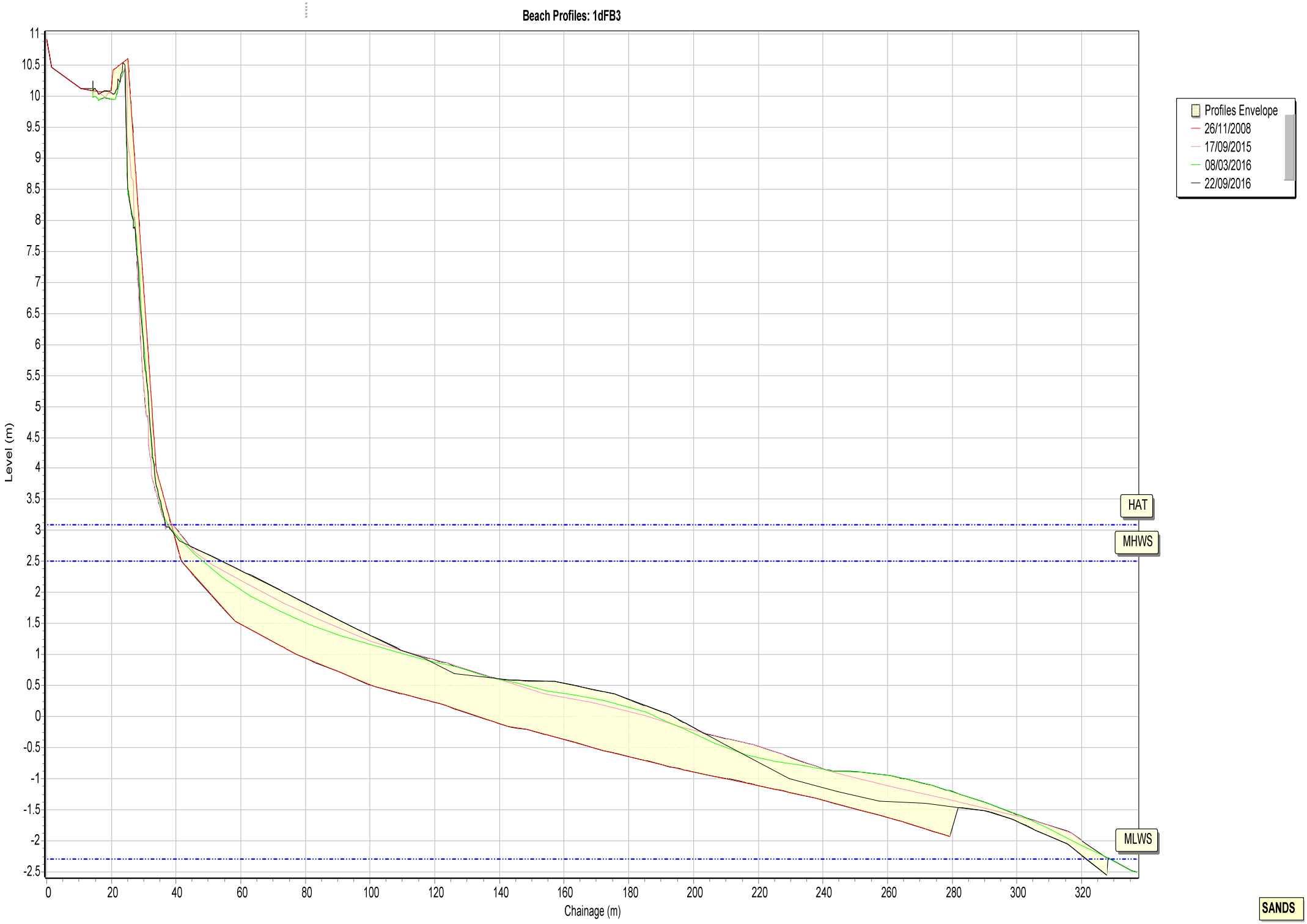

Beach Profiles: 1dFB2
Profiles Envelope
26/11/2008
17/09/2015
08/03/2016
22/09/2016
Level (m)
Chainage (m)
HAT
MHWS
MLWS
SANDS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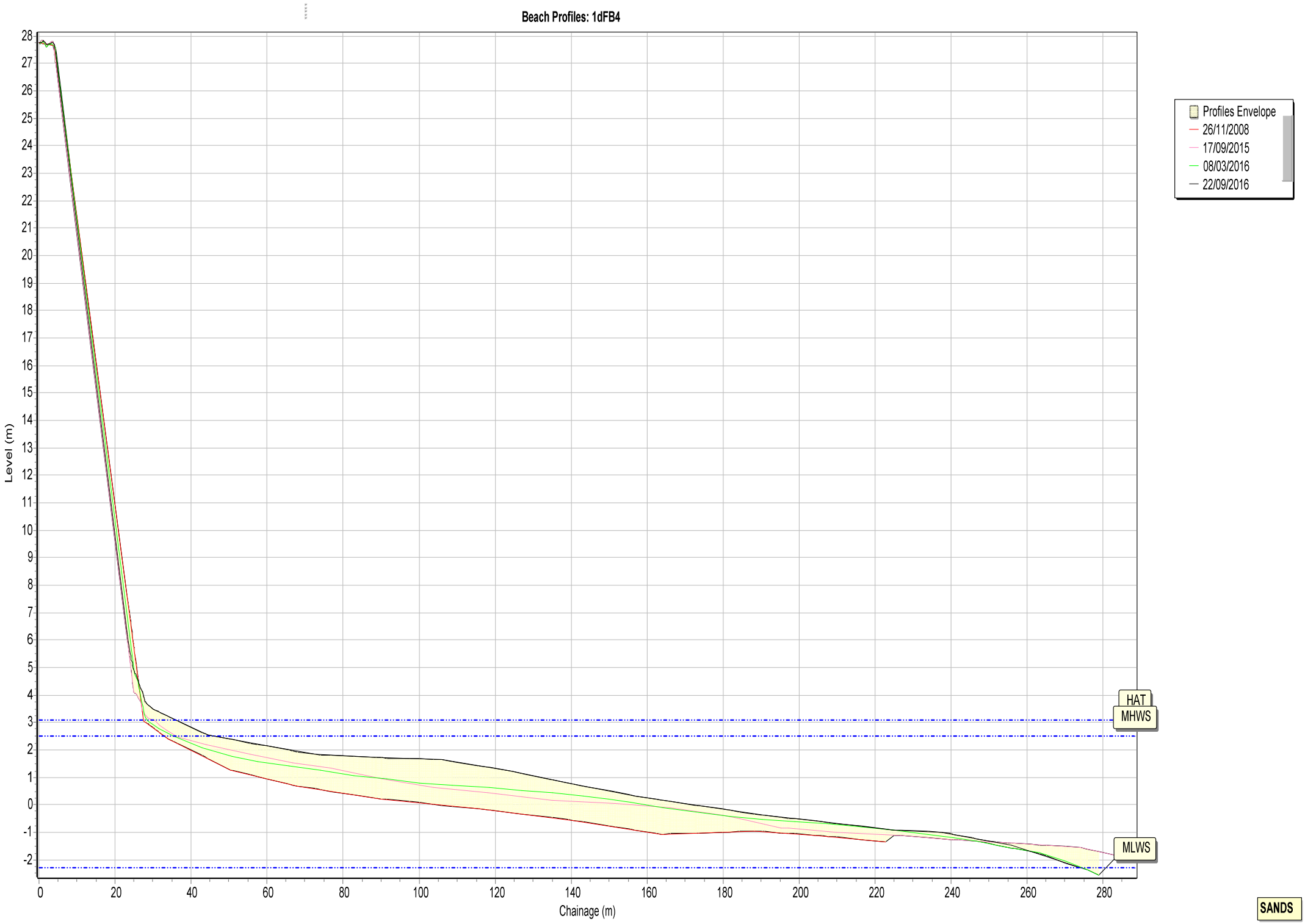
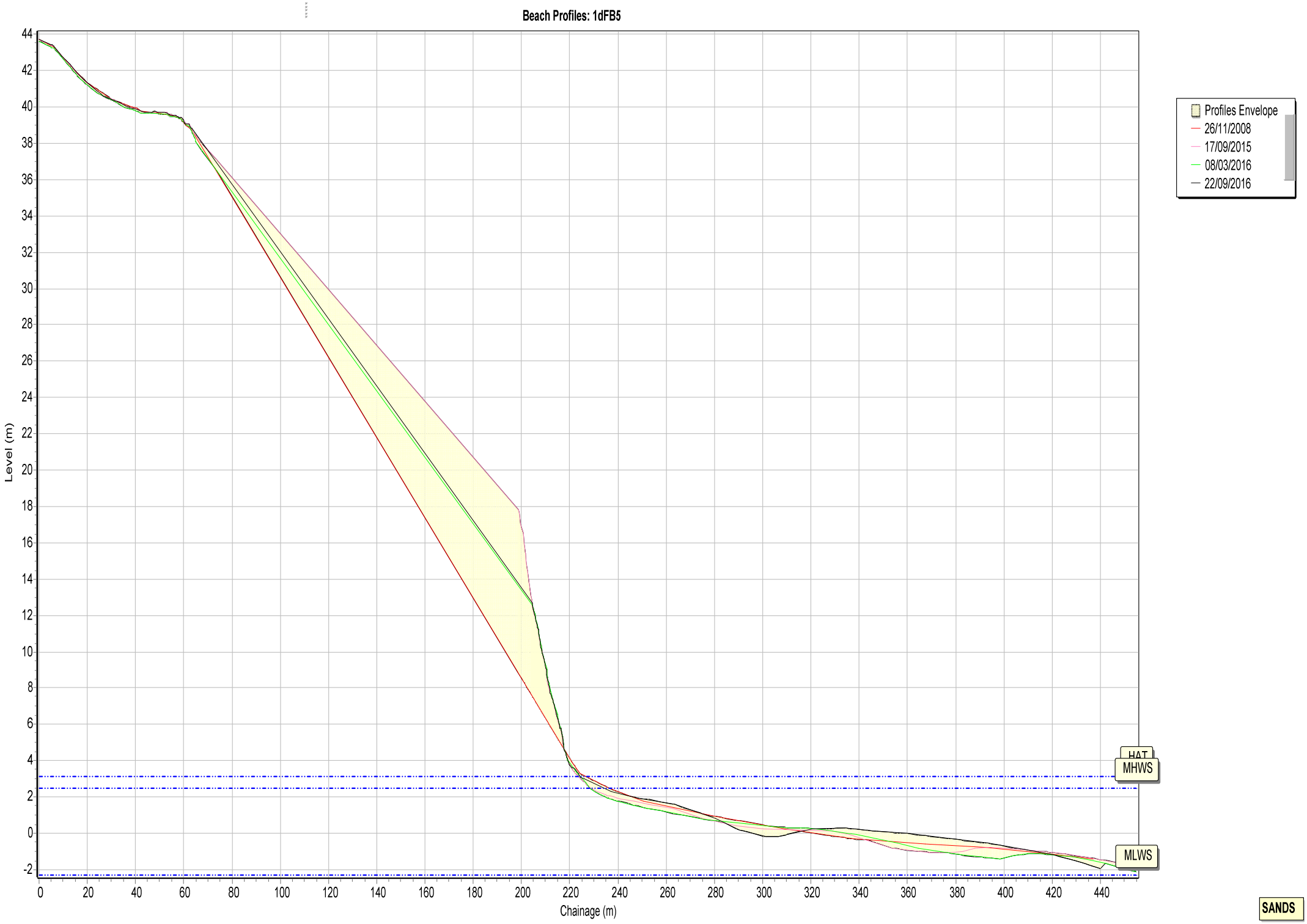
Profiles Envelope
26/11/2008
17/09/2015
08/03/2016
22/09/2016
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS


Beach Profiles: 1dFB4
Profiles Envelope
26/11/2008
17/09/2015
08/03/2016
22/09/2016
Level (m)
Chainage (m)
HAT
MHWS
MLWS
SANDS

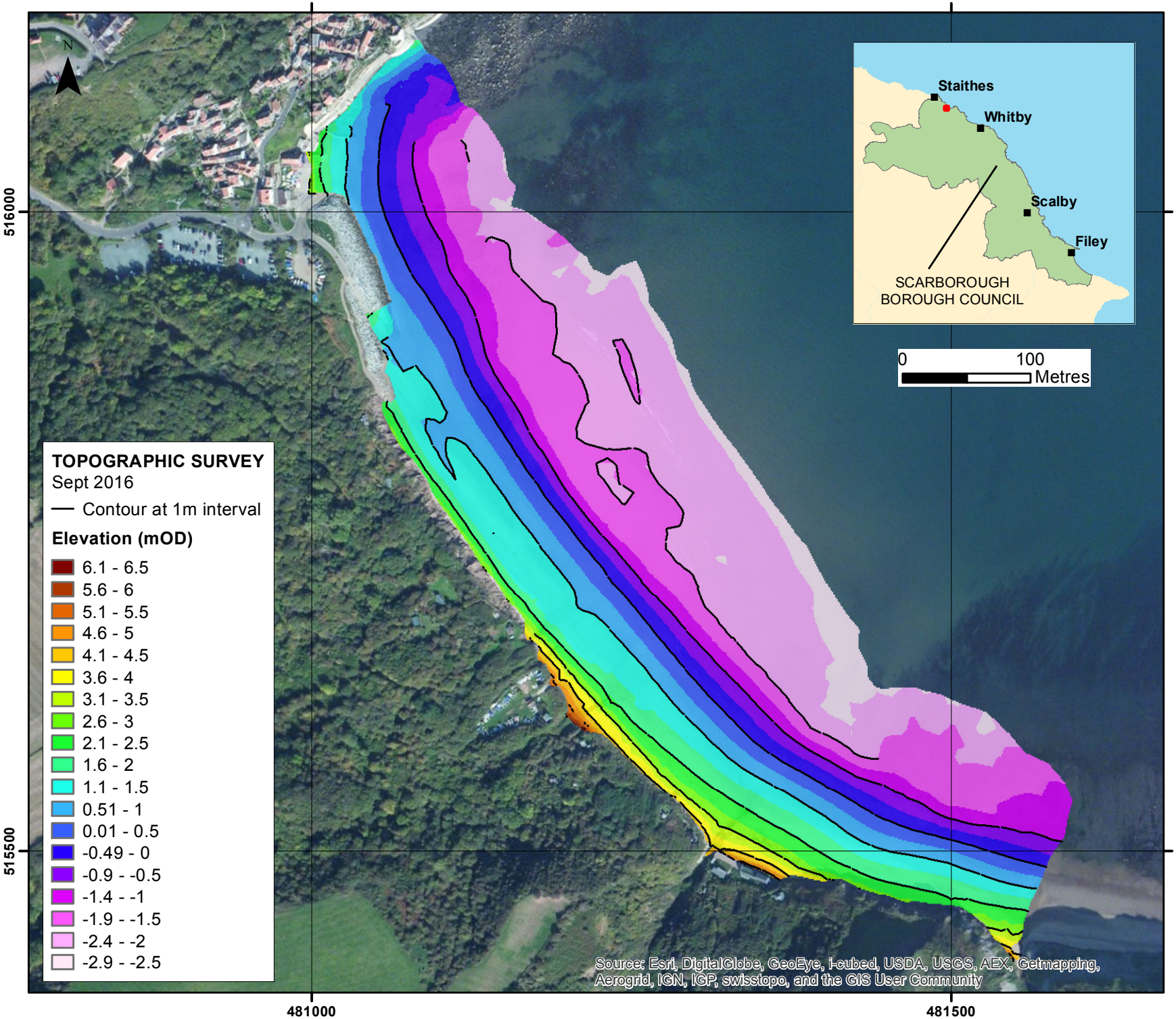

Beach Profiles: 1dFB5
Profiles Envelope
26/11/2008
17/09/2015
08/03/2016
22/09/2016
Level (m)
Chainage (m)
HAT
MHWS
MLWS
SANDS

The following sediment feature codes are used on some profile plots:

Code	Description
S	Sand
M	Mud
G	Gravel
GS	Gravel & Sand
MS	Mud & Sand
B	Boulders
R	Rock
SD	Sea Defence
SM	Saltmarsh
W	Water Body
GM	Gravel & Mud
GR	Grass
D	Dune (non-vegetated)
DV	Dune (vegetated)
F	Forested
X	Mixture
FB	Obstruction
CT	Cliff Top
CE	Cliff Edge
CF	Cliff Face
SH	Shell
ZZ	Unknown

Appendix B

Topographic Survey



Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 1

RUNSWICK BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:4,000

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Marlborough Crescent
Newcastle upon Tyne
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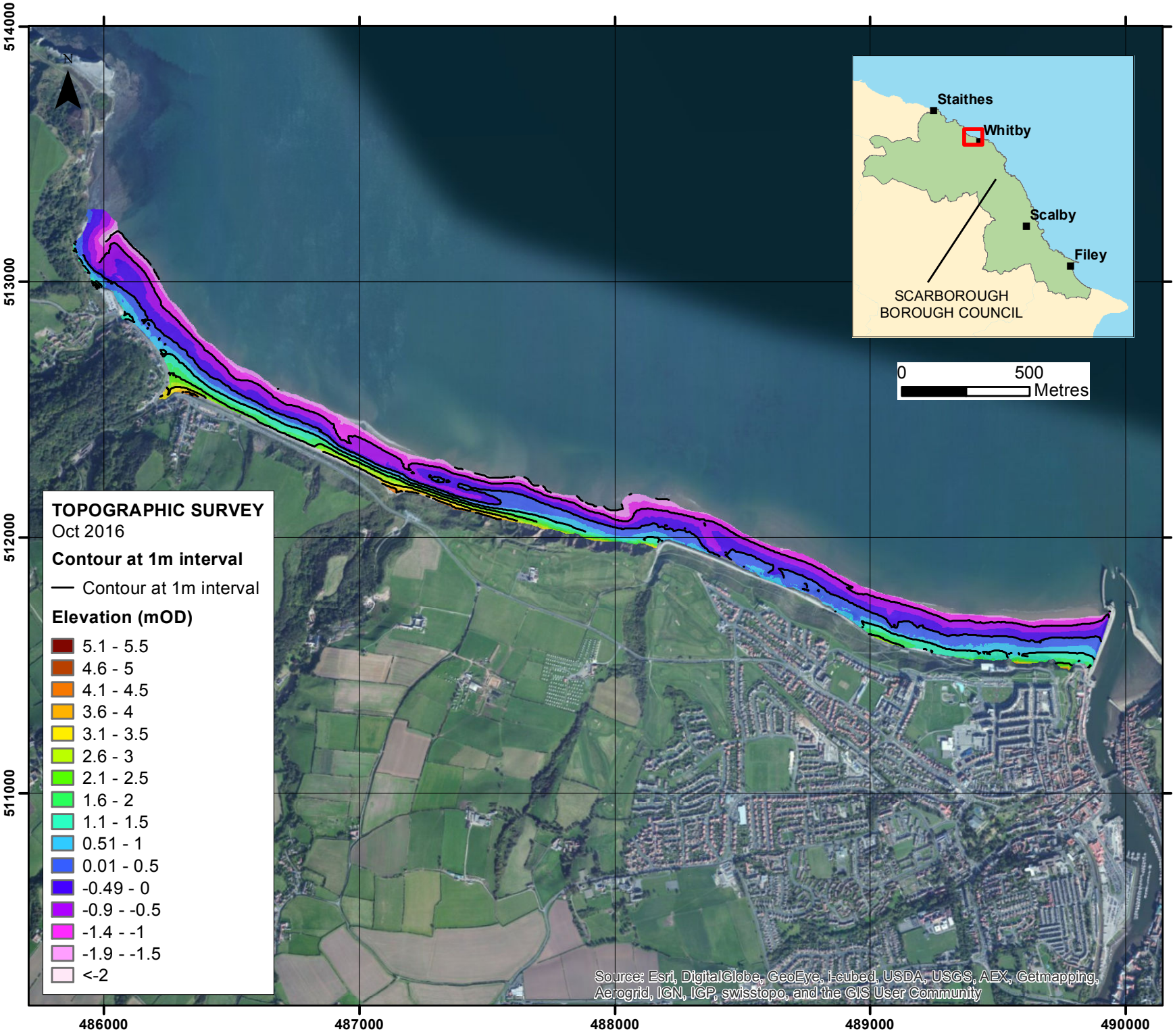

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 2

SANDSEND

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:20,000

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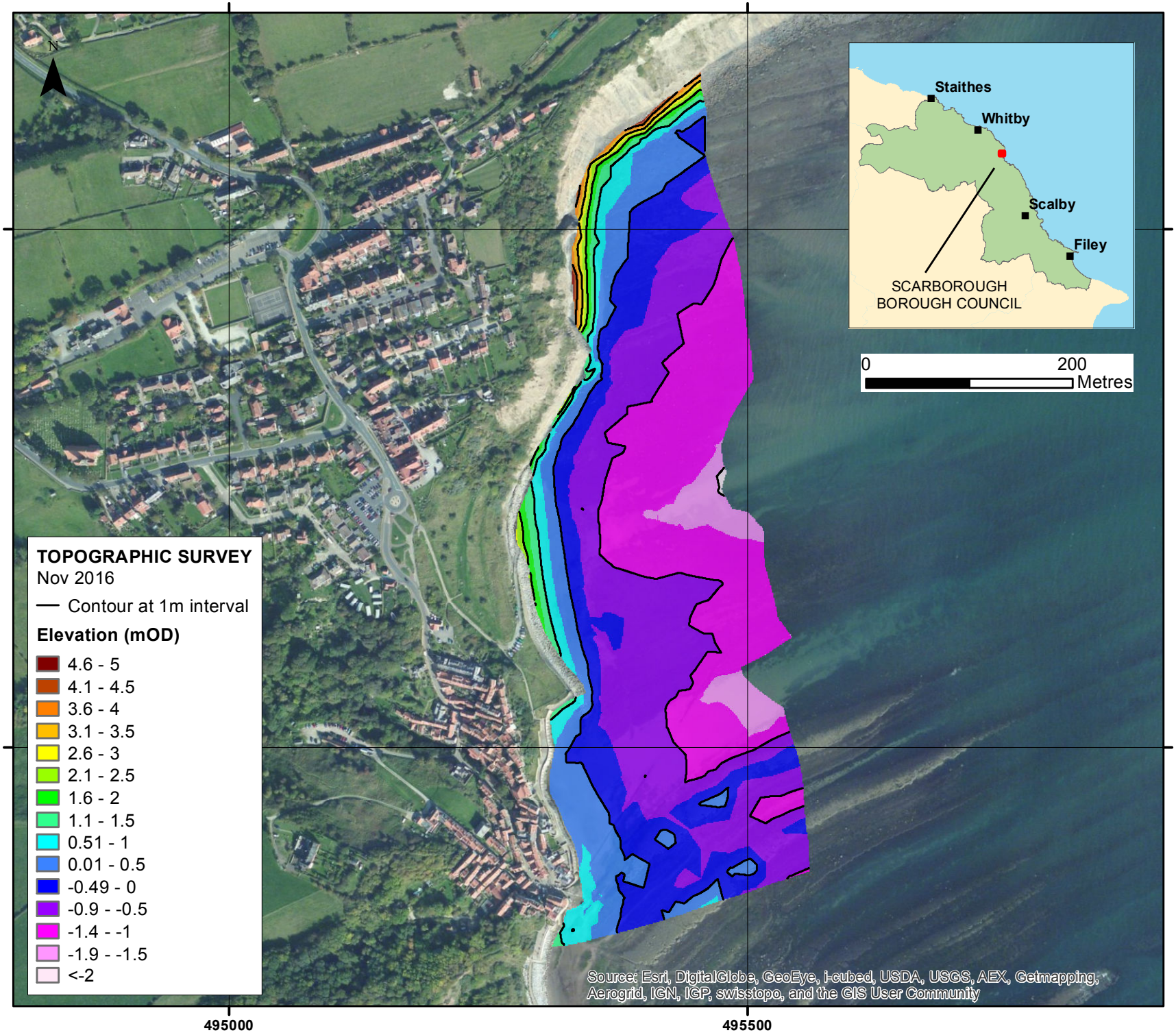

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3

ROBIN HOOD'S BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:5,000

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Marlborough Crescent
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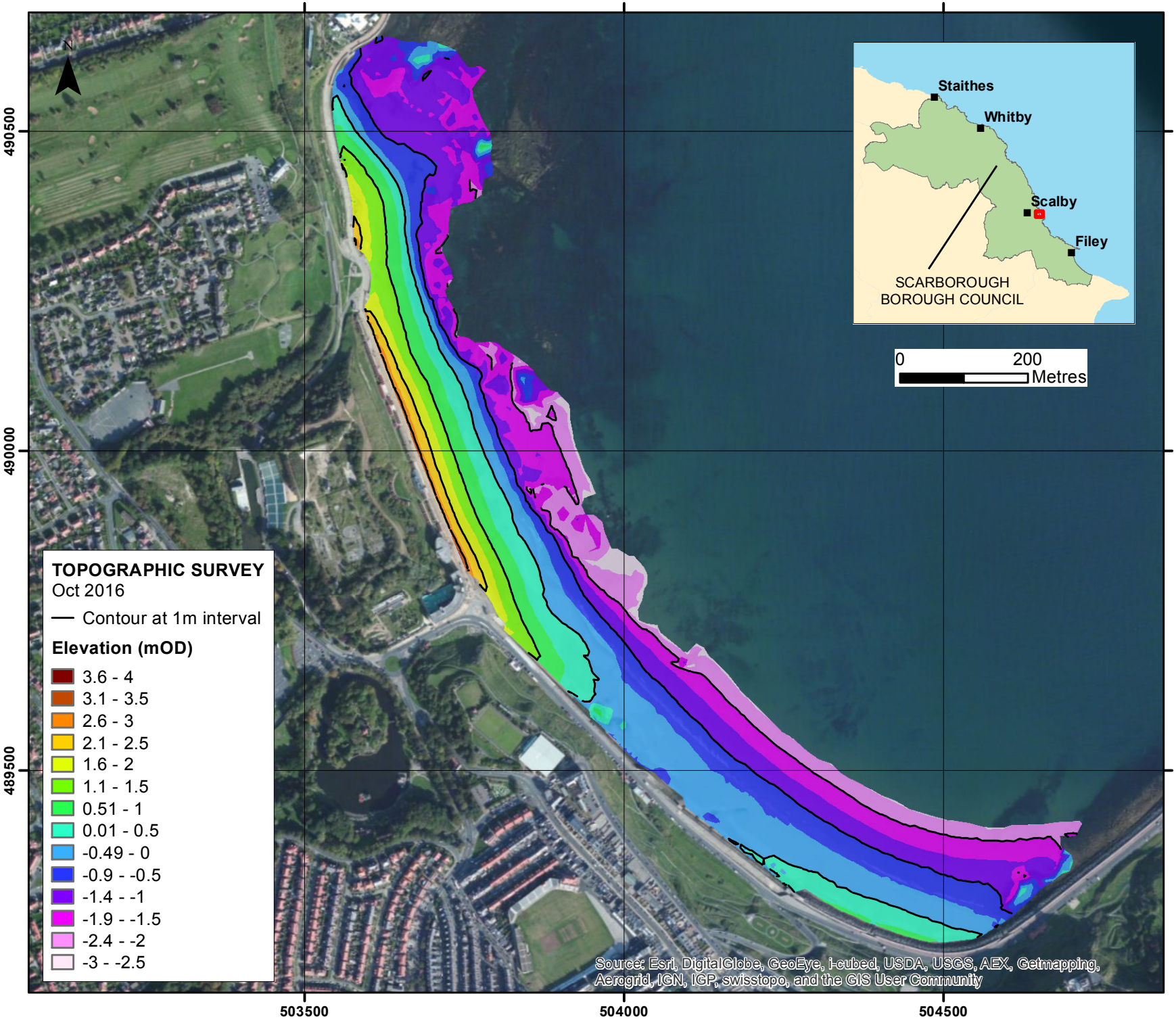

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4

SCARBOROUGH NORTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:8,000

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Marlborough Crescent
Newcastle upon Tyne
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Fax: +44 (0)191 211 1313
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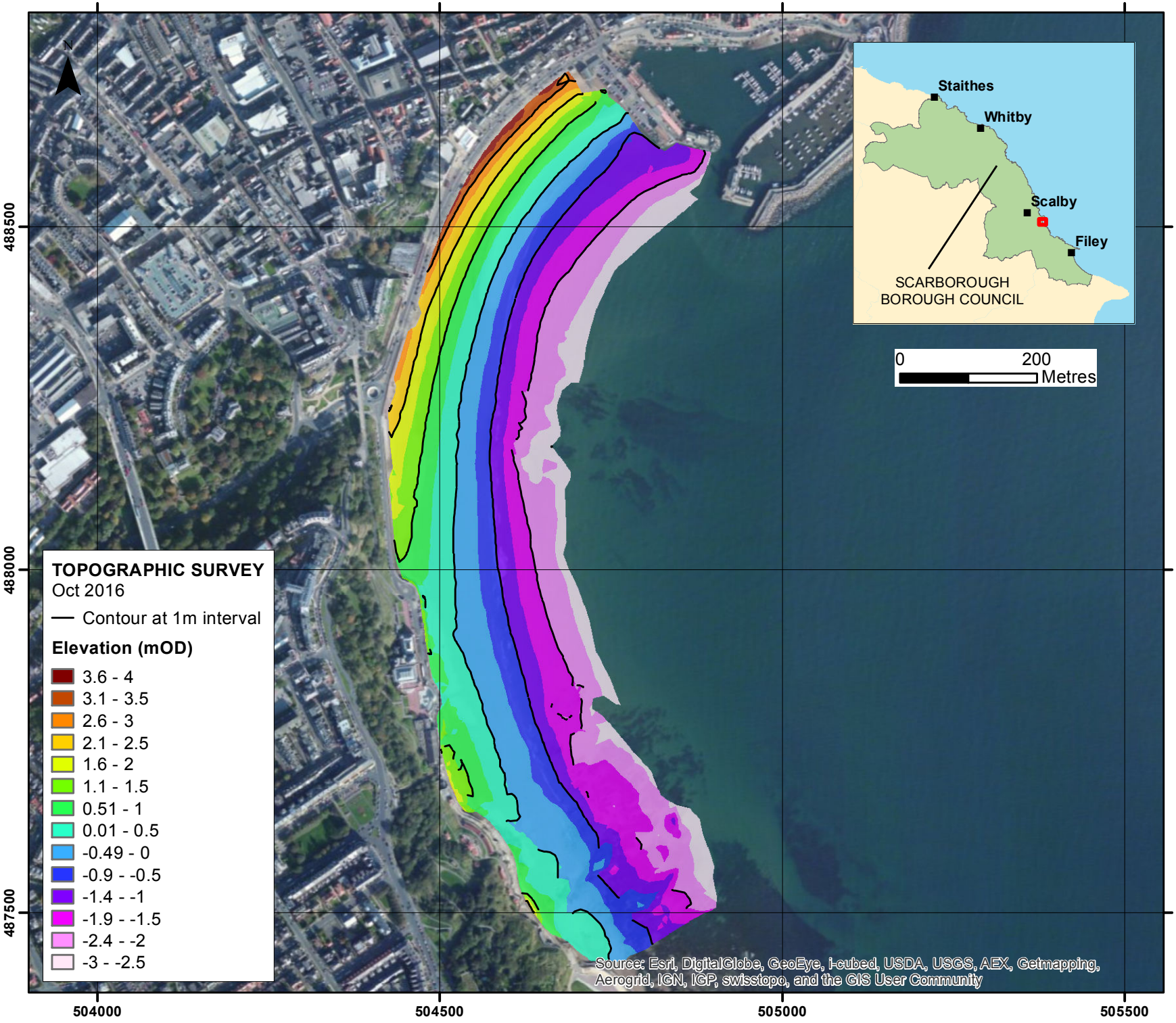

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 5

SCARBOROUGH SOUTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:7,462

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Marlborough Crescent
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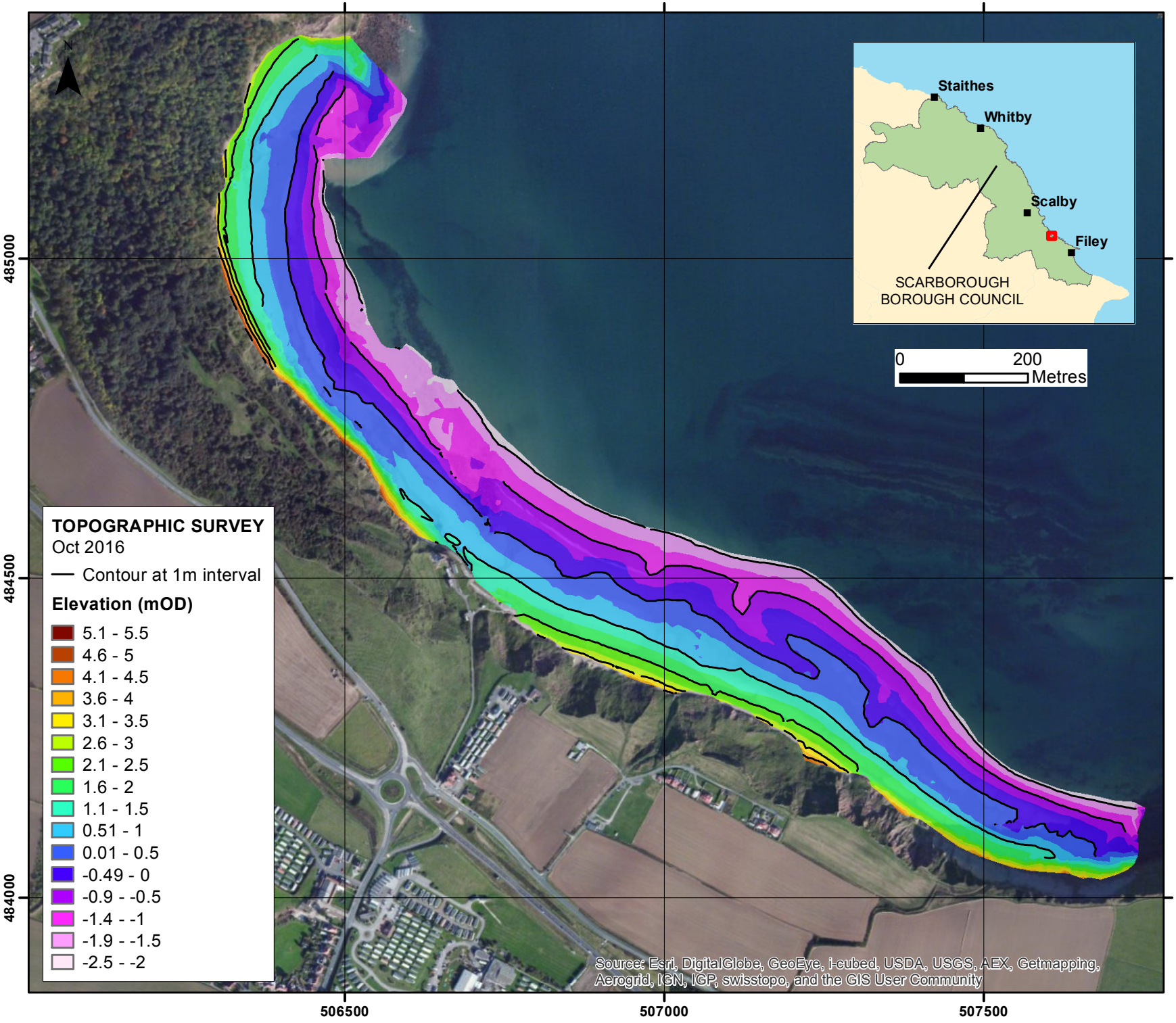

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 6

CAYTON BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:8,000

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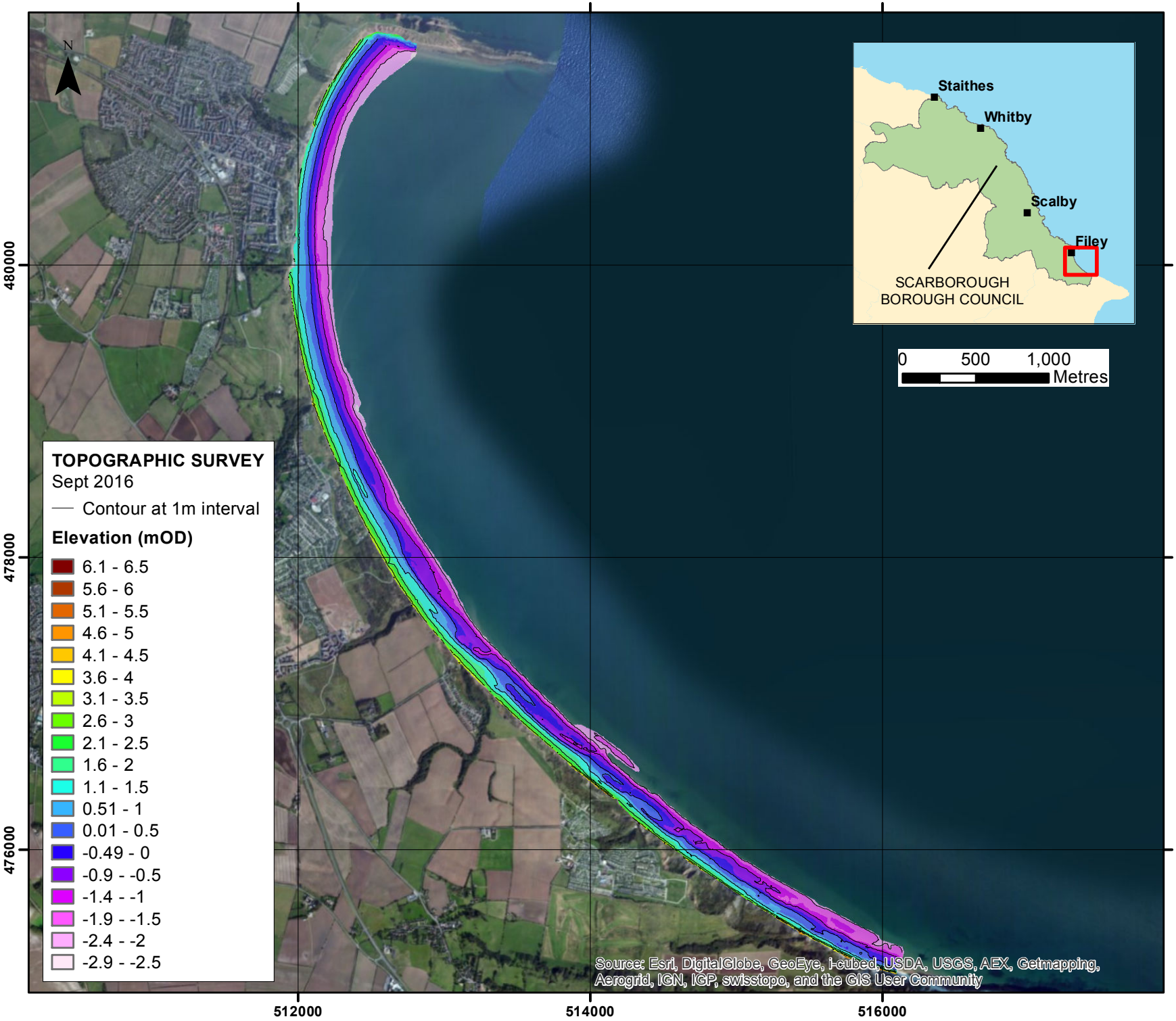

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 7

FILEY BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:35,000

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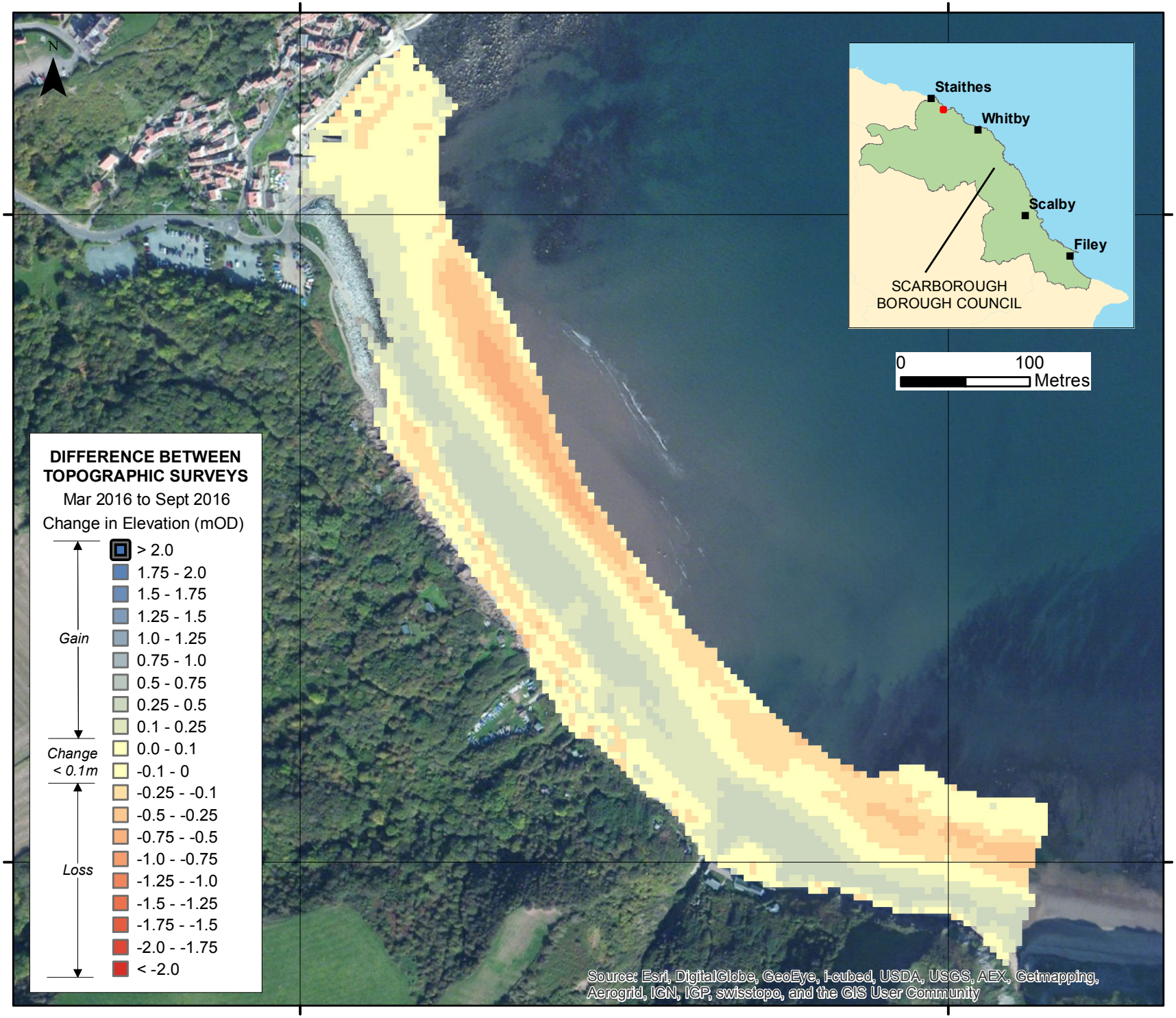

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 8

RUNSWICK BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:4,000

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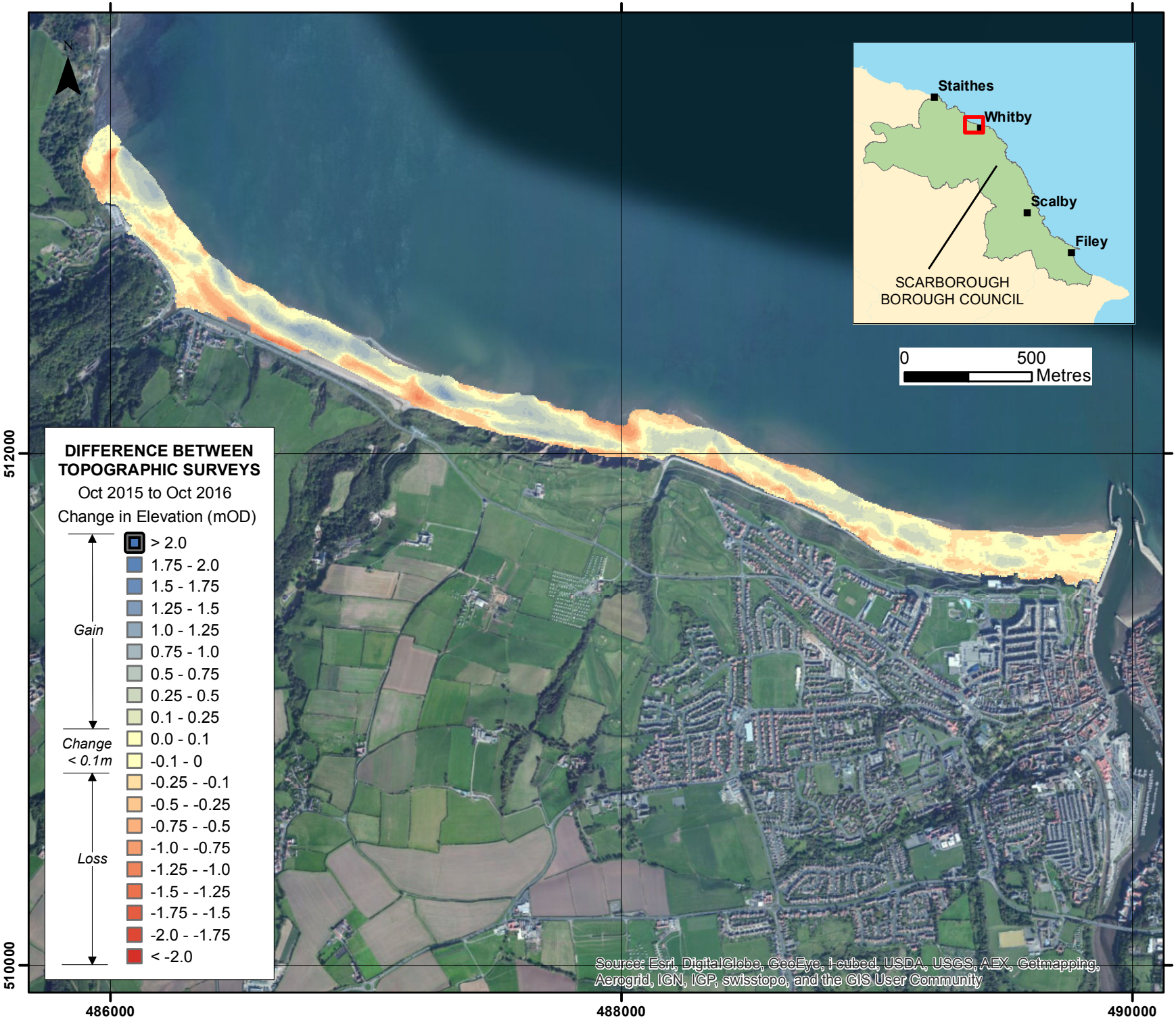

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 9

SANDSEND

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:20,000

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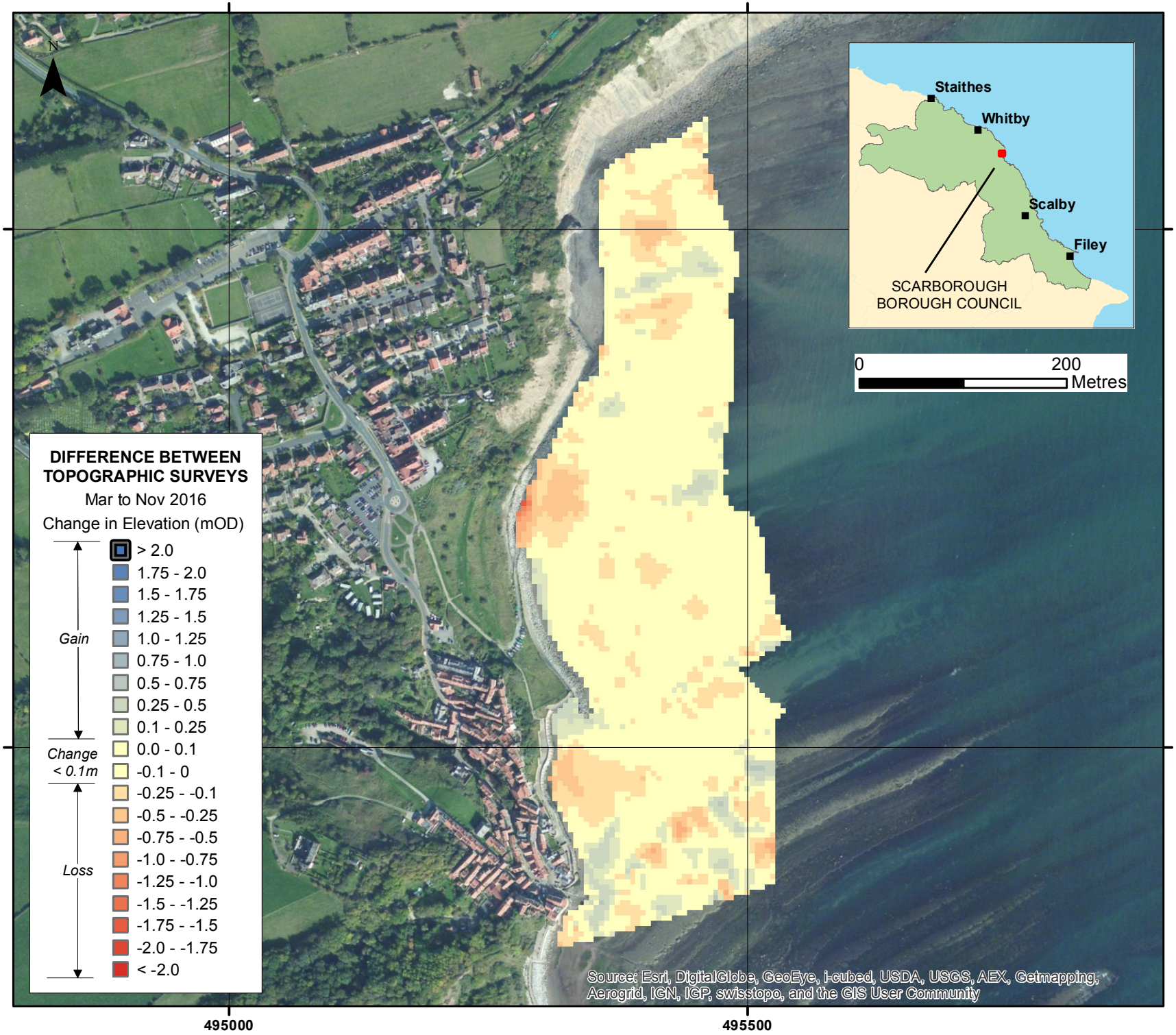

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 10

ROBIN HOOD'S BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:5,000

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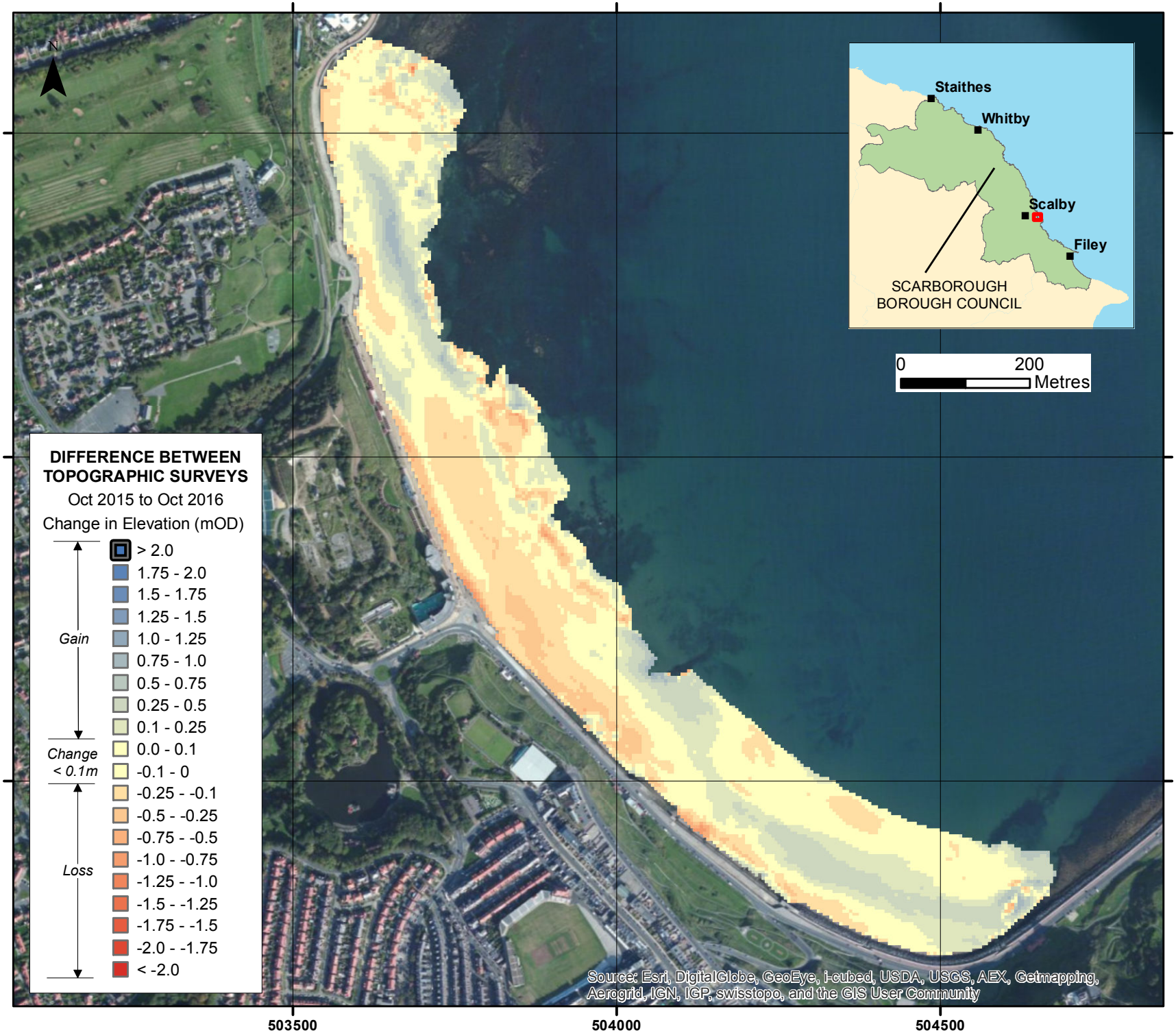

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 11

SCARBOROUGH NORTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:8,000

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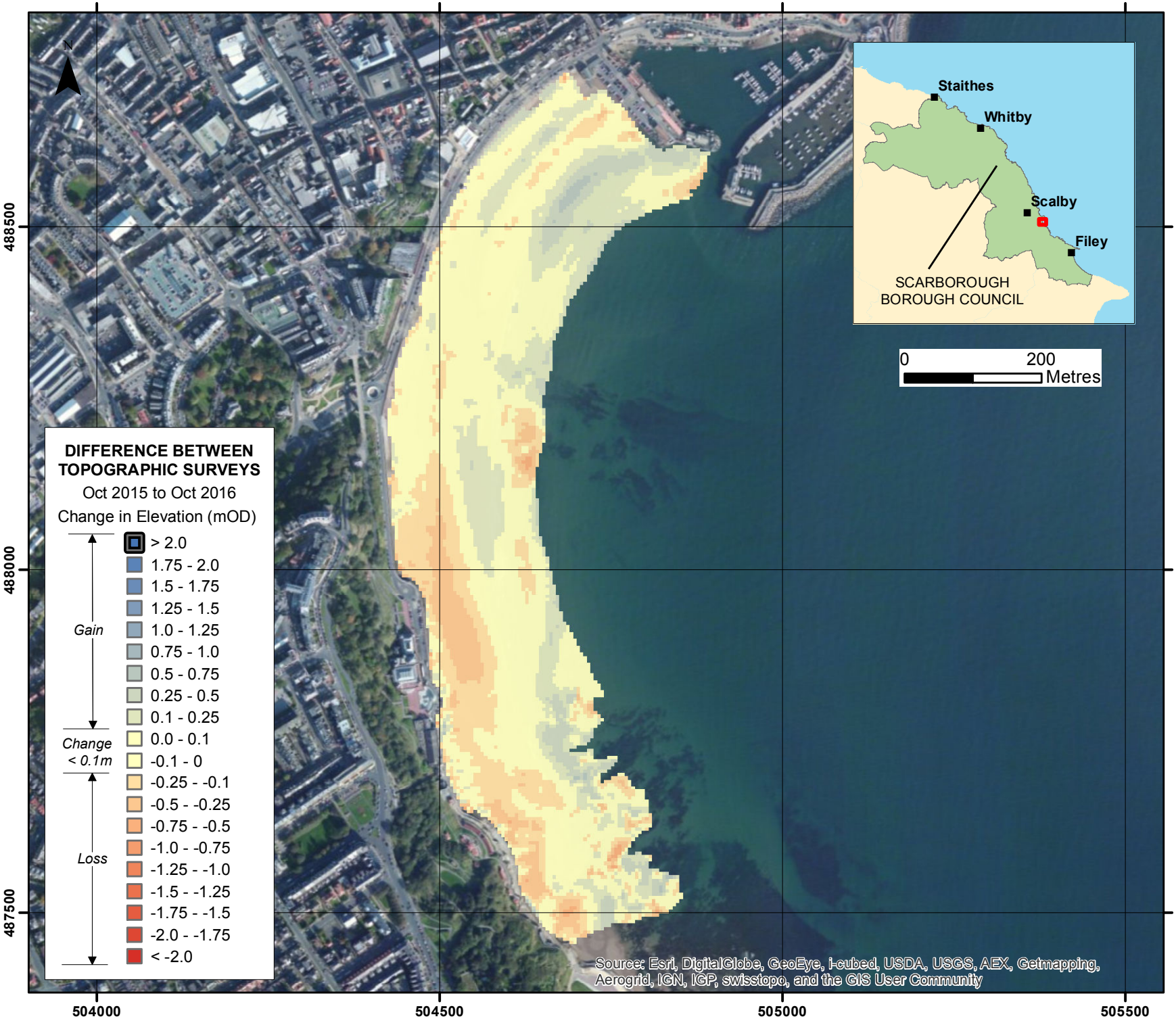

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 12

SCARBOROUGH SOUTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:7,458

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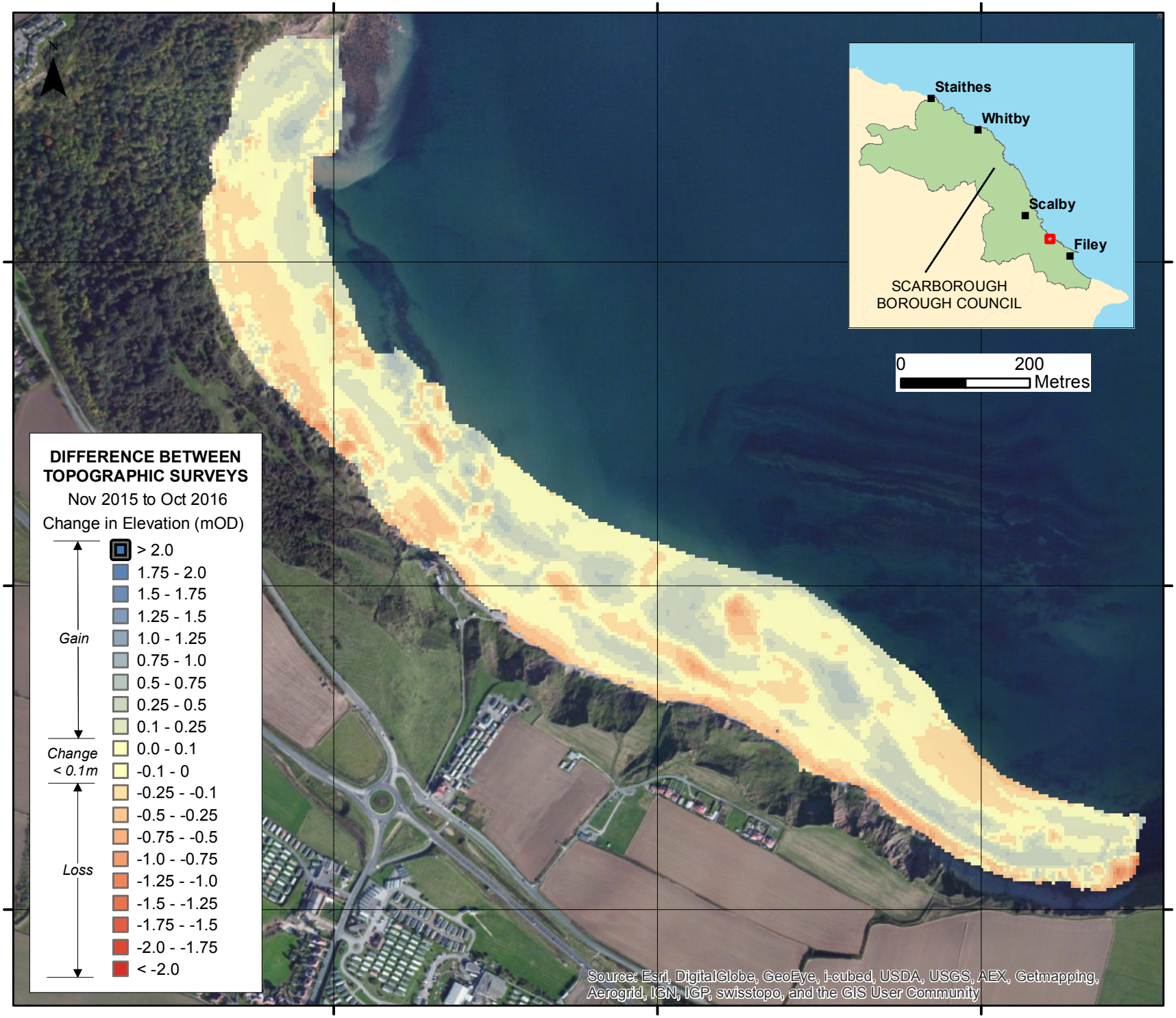

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 13

CAYTON BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:8,000

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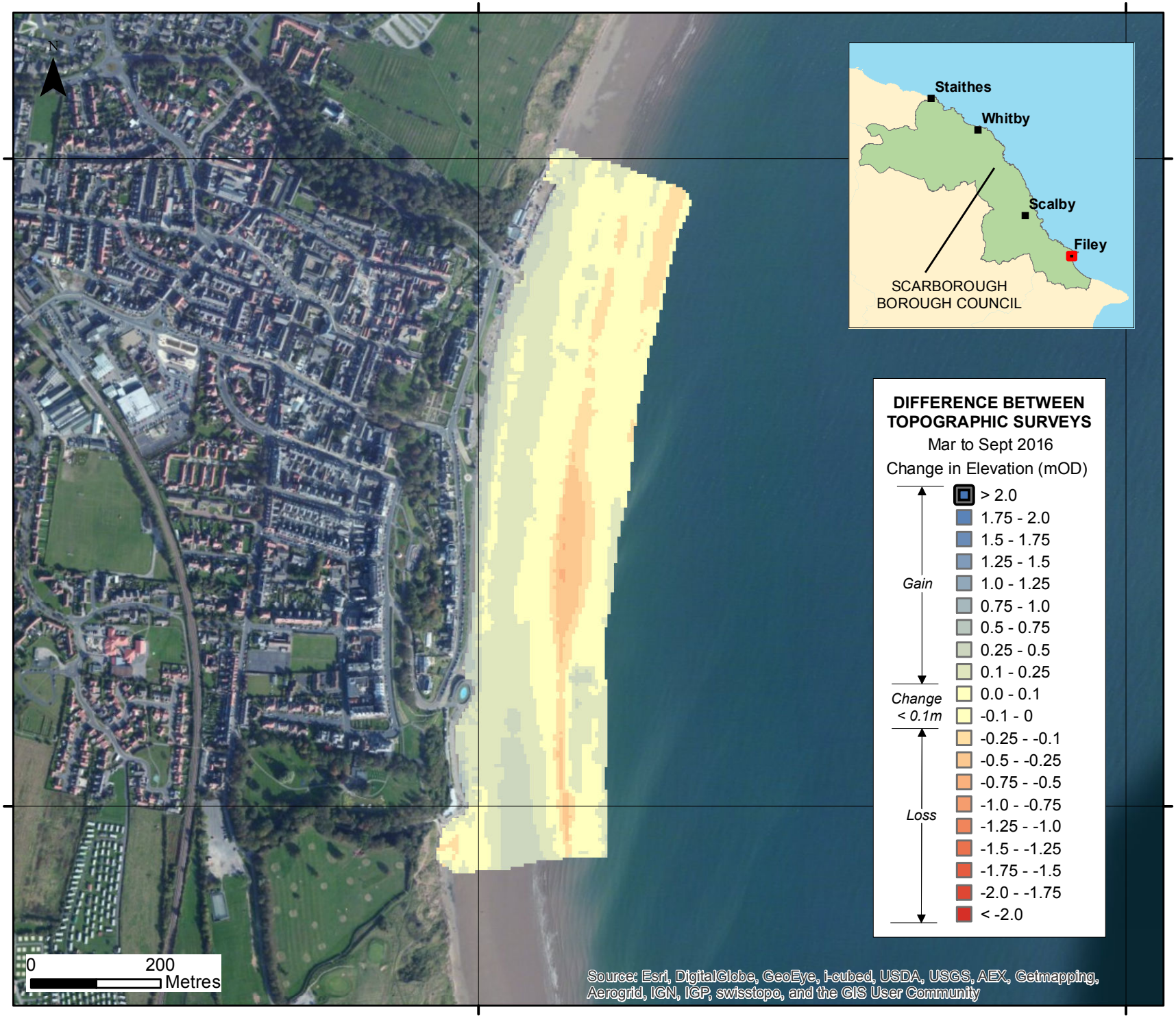

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 14

FILEY BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:8,000

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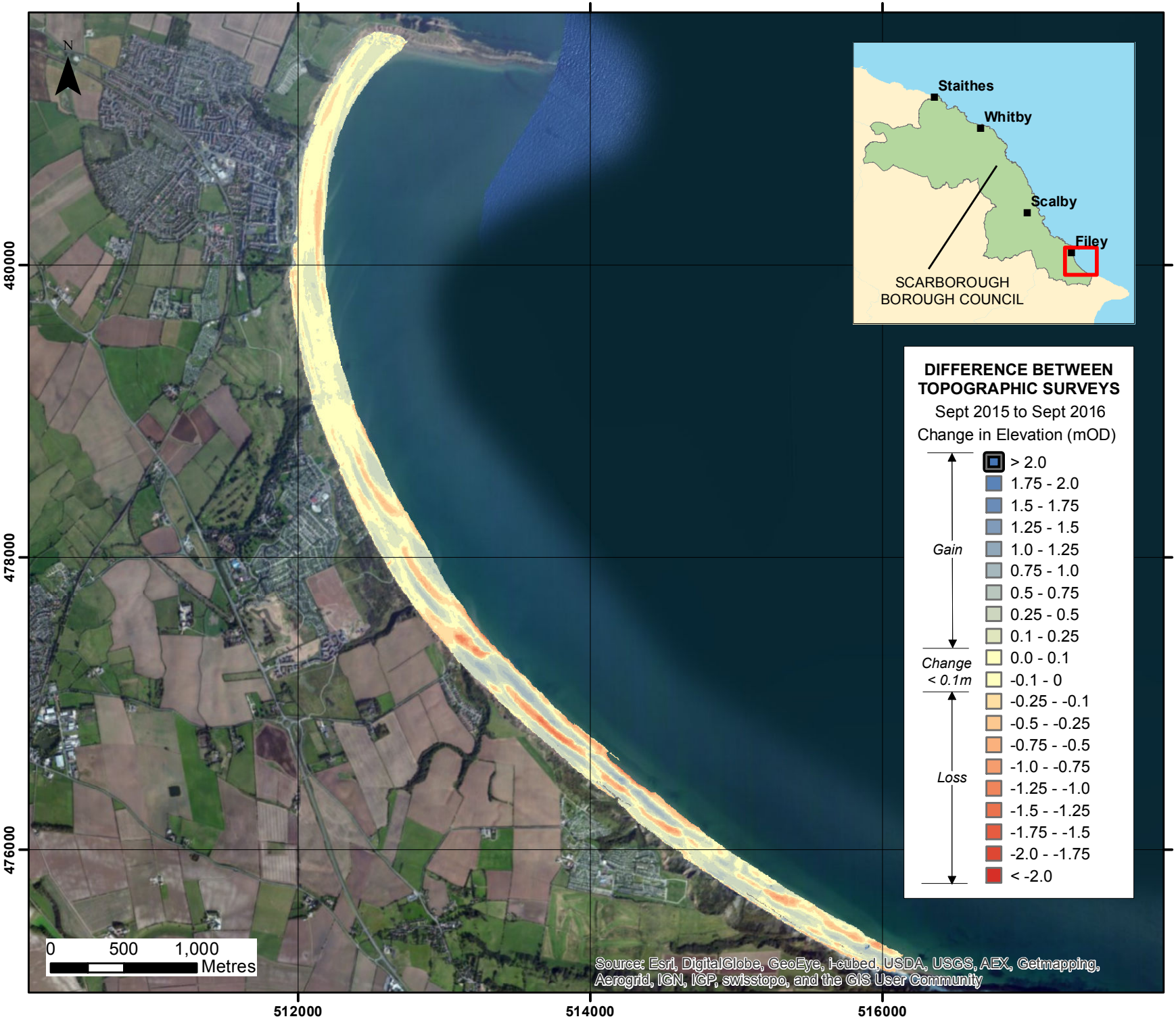

DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS

Sept 2015 to Sept 2016

Change in Elevation (mOD)

Gain	> 2.0
	1.75 - 2.0
	1.5 - 1.75
	1.25 - 1.5
	1.0 - 1.25
	0.75 - 1.0
	0.5 - 0.75
	0.25 - 0.5
	0.1 - 0.25
Change < 0.1m	0.0 - 0.1
	-0.1 - 0
Loss	-0.25 - -0.1
	-0.5 - -0.25
	-0.75 - -0.5
	-1.0 - -0.75
	-1.25 - -1.0
	-1.5 - -1.25
	-1.75 - -1.5
	-2.0 - -1.75
	< -2.0

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 15

FILEY BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:35,000

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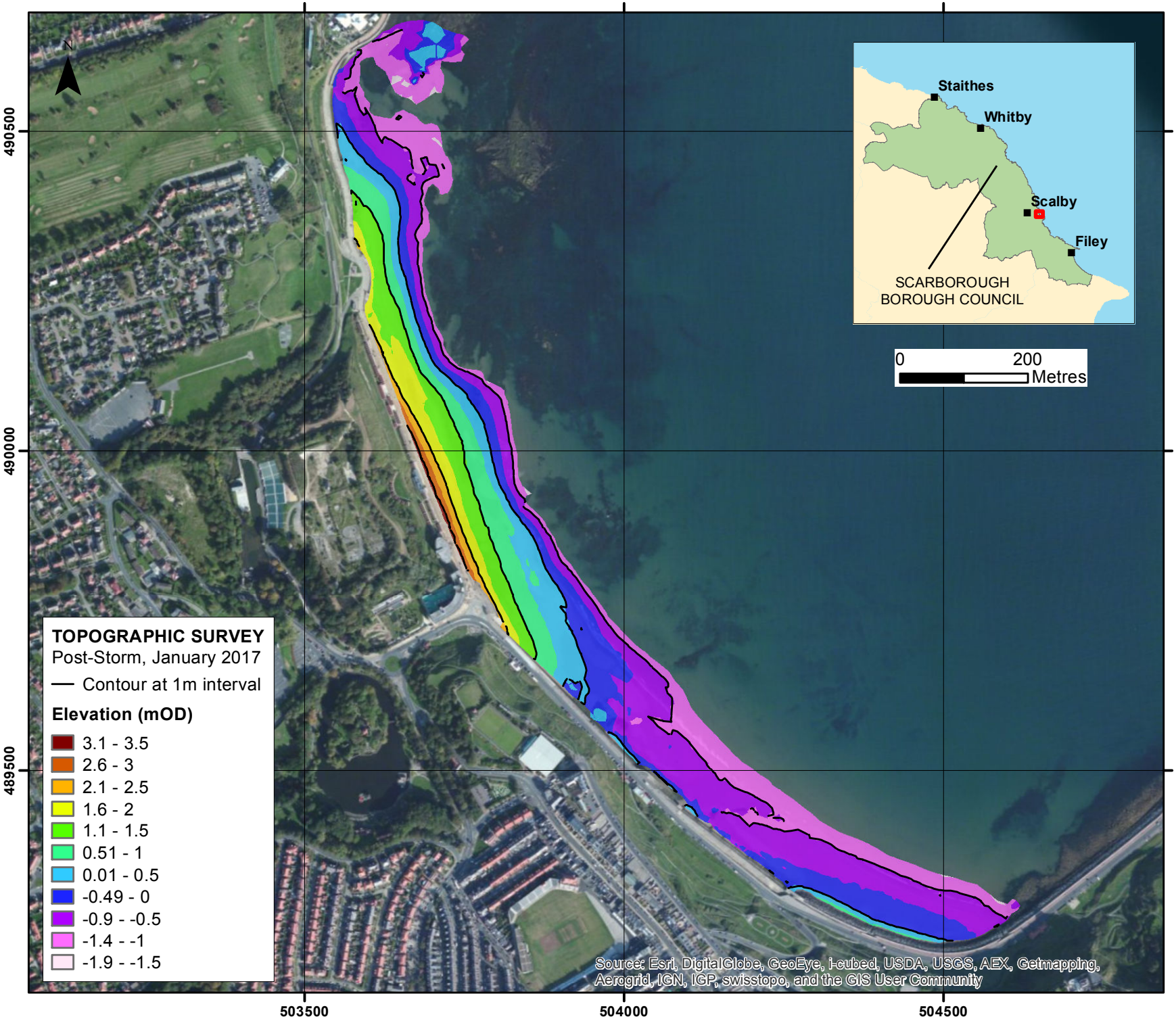

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 16

SCARBOROUGH NORTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:8,000

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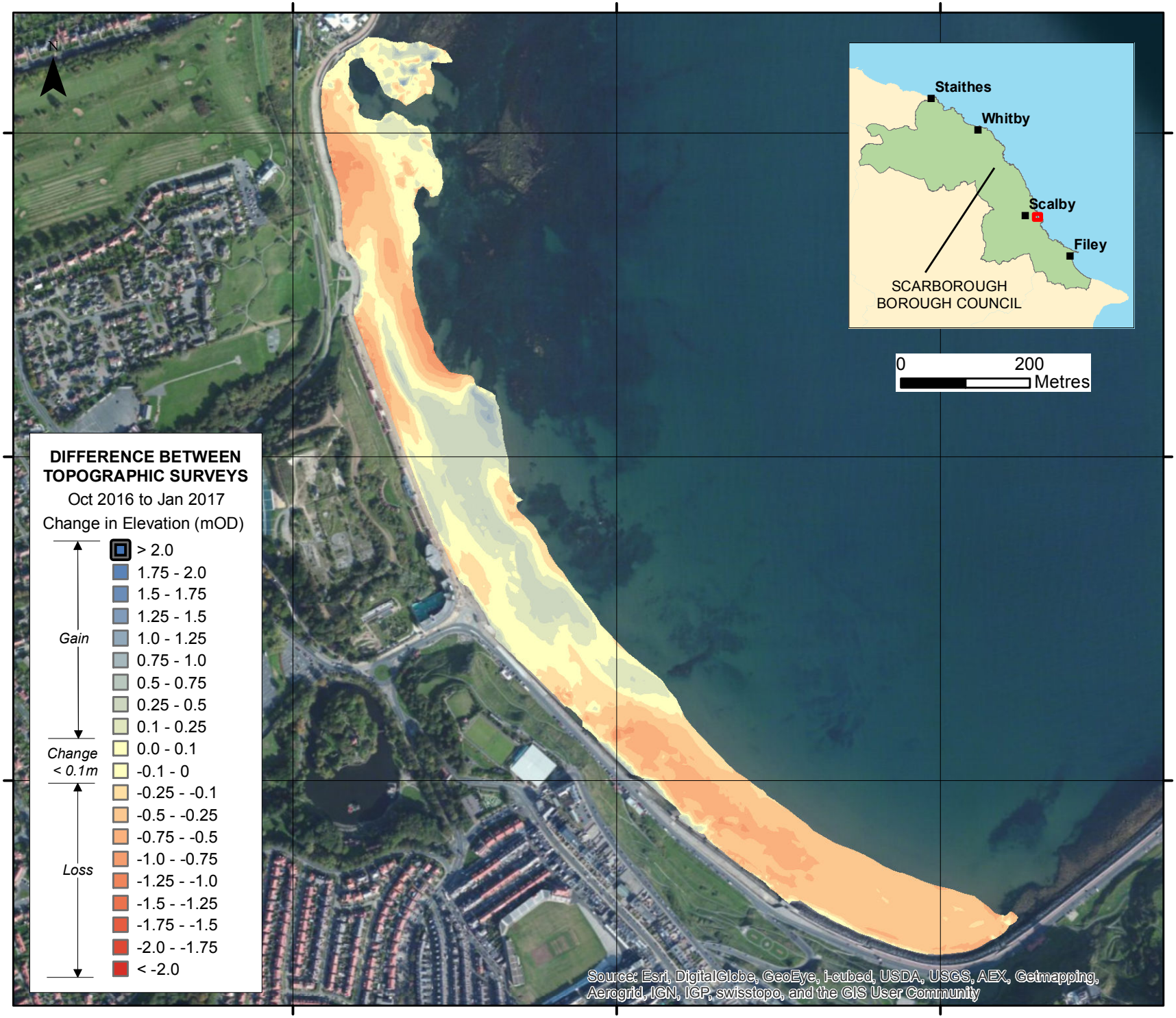

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 17

SCARBOROUGH NORTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:8,000

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Appendix C

Cliff Top Survey

Cliff Top Survey

Staithes

Twenty ground control points have been established within Staithes (Figure C1). The maximum separation between any two points is nominally 100m. The cliff top surveys at Staithes are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table C1 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C1 – Cliff Top Surveys at Staithes

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
			(°)	Nov 2008	April 2016	Sept 2016	Nov 2008 - Sep 2016	Apr 2016 - Sep 2016	Nov 2008 - Sep 2016
1	477228	518769	320	1.9	1.6	1.62	0.28	-0.02	0.04
2	477334	518798	0	10.9	10.8	10.73	0.17	0.07	0.02
3	477487	518789	350	7.1	8.4	8.14	-1.04	0.26	0.00
4	477594	518801	340	5.9	4.5	4.48	1.42	0.02	0.18
5	477683	518911	350	8.4	8.5	8.75	-0.35	-0.25	0.00
6	477792	518867	30	8.6	8.6	8.39	0.21	0.21	0.03
7	477891	518828	60	7.7	7.6	7.31	0.39	0.29	0.05
8	477959	518873	350	8.7	9.7	9.6	-0.90	0.10	0.00
9	478088	518950	350	7.6	8.1	No Access	-0.50		0.00
10	478191	519023	340	8.4	8.8	No Access	-0.40		0.00
11	478237	519007	60	6.9	6.7	No Access	0.20		0.03
12	478213	518988	150	6.1	7.4	No Access	-1.30		0.00
13	478501	518809	15	11.4	9.2	9.07	2.33	0.13	0.29
14	478624	518807	20	7.5	7.5	7.44	0.06	0.06	0.01

15	478737	518858	60	6.1	6.3	6.33	-0.23	-0.03	0.00
16	478823	518757	60	8	8.6	8.58	-0.58	0.02	0.00
17	478944	518671	30	9.3	9.2	9.24	0.06	-0.04	0.01
18	479052	518630	20	9.2	8.7	8.87	0.33	-0.17	0.04
19	479147	518610	0	14.2	13.8	13.79	0.41	0.01	0.05
20	479274	518618	20	11.4	11	11.33	0.07	-0.33	0.01

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Note: Shaded cells use the April 2016 Partial measures survey data for calculations, as access was unavailable for the 2016 full measures survey.

Robin Hoods Bay

Thirteen ground control points have been established within Robin Hoods Bay (Figure C1). The maximum separation between any two points is nominally 200m.

The cliff top surveys at Robin Hoods Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table C2 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C2 – Cliff Top Surveys at Robin Hoods Bay

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
			(°)	Mar 2010	Mar 2016	Nov 2016	Mar 2010 - Nov 2016	Mar 2016 - Nov 2016	Mar 2010 - Nov 2016
1	495799.5	506002.2	130	11.6	8	7.87	3.73	0.13	0.62
2	495549.2	505807.3	135	9.3	9.2	9.04	0.26	0.16	0.04
3	495456.3	505740	130	5	5.2	5.09	-0.09	0.11	0.00
4	495389.9	505683.7	140	6.3	6.2	6.18	0.12	0.02	0.02
5	495259.4	505342.5	130	11.3	12.7	12.58	-1.28	0.12	0.00
6	495231.2	505315.7	95	5.9	5.8	5.81	0.09	-0.01	0.02
7	495184.8	505210.7	85	6.4	6.7	6.73	-0.33	-0.03	0.00
8	495206.5	505153	75	5	5.2	5.22	-0.22	-0.02	0.00
9	495287.8	505060.5	80	4.3	4.5	4.57	-0.27	-0.07	0.00
10	495187.8	504708.8	70	3.1	2.5	2.43	0.67	0.07	0.11
11	495226.2	504615.7	120	3.8	3.9	3.93	-0.13	-0.03	0.00
12	495297.5	504380.2	80	11	11	11.04	-0.04	-0.04	0.00
13	495350.4	504193	55	3.7	3.8	3.78	-0.08	0.02	0.00

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Scarborough South Bay

Thirteen ground control points have been established between Scarborough South Bay and Cayton Bay (Figure C1). The maximum separation between any two points is nominally 300m.

The cliff top surveys at Scarborough South Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table C3 provides baseline information about these ground control points and results from the 2010 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C3 – Cliff Top Surveys at Scarborough South

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
			(°)	Mar 2010	Mar 2016	Oct 2016	Mar 2010 - Oct 2016	Mar 2016 - Oct 2016	Mar 2010 - Oct 2016
1	504339.5	487887.3	70	7	7	6.96	0.04	0.04	0.01
2	504422.3	487603.7	80	4.8	4.8	4.83	-0.03	-0.03	0.00
3	504534.8	487318.3	40	15.1	15.1	15.12	-0.02	-0.02	0.00
4	504730.2	487137.9	55	9.6	9.6	9.59	0.01	0.01	0.00
5	504922.9	486837.8	60	8.8	8.7	8.71	0.09	-0.01	0.02
6	50571.1	486652.1	75	3.8	3.7	3.77	0.03	-0.07	0.00
7	505284.3	486480	35	7	6.8	6.52	0.48	0.28	0.08
8	505597.9	486363.4	30	8.6	8.2	8.44	0.16	-0.24	0.03
9	505758.6	486005.1	45	9.1	8.7	8.63	0.47	0.07	0.08
10	505896	485889.6	15	14.8	14.7	14.76	0.04	-0.06	0.01
11	505990	485657.1	80	4.7	1.2	1.18	3.52	0.02	0.59
12	506024.9	485421.8	55	6.1	3.3	3.19	2.91	0.11	0.49
13	506036	485315.3	90	7	7.1	7.04	-0.04	0.06	0.00

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Cayton Bay

Eight ground control points have been established within Cayton Bay (Figure C1). The maximum separation between any two points is nominally 300m.

The cliff top surveys at Cayton Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table C4 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C4 – Cliff Top Surveys at Cayton Bay

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
			(°)	Nov 2008	Mar 2016	Oct 2016	Nov 2008 - Oct 2016	Mar 2016 - Oct 2016	Nov 2008 - Oct 2016
1	506325.5	484849.7	50	4	3.7	3.67	0.33	0.03	0.04
2	506459.4	484715.9	65	5	0.1	0.17	4.83	-0.07	0.60
3	506597.4	484538.6	65	5	6.4	6.26	-1.26	0.14	0.00
4	506778.1	484345.5	21	9	6.2	5.99	3.01	0.21	0.38
5	507018.6	484221.6	342	7.7	8.1	7.82	-0.12	0.28	0.00
6	507242.3	484121.7	2	7.4	6.2	6.17	1.23	0.03	0.15
7	507518.2	484008.2	25	7.5	7.9	7.81	-0.31	0.09	0.00
8	507818.7	484006	1	5.5	6.1	5.92	-0.42	0.18	0.00

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Filey Bay

Twenty-seven ground control points have been established within Filey Bay (Figure C1). The maximum separation between any two points is nominally 300m.

The cliff top surveys at Filey Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table C5 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C5 – Cliff Top Surveys at Filey Bay

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
			(°)	Nov 2008	Mar 2016	Sep 2016	Nov 2008 - Sep 2016	Mar 2016 - Sep 2016	Nov 2008 - Sep 2016
1	512444.9	481630.9	130	8.7	8.8	8.79	-0.09	0.01	0.00
2	512306.7	481490.3	144	7.6	7.8	7.78	-0.18	0.02	0.00
3	512153.6	481234.6	122	8.3	8.3	8.16	0.14	0.14	0.02
4	512029.2	480959.9	115	7.4	7.4	7.51	-0.11	-0.11	0.00
5	511895.4	479888	89	7.1	0.7	0.7	6.40	0.00	0.80
6	511908.5	479597.1	48	6.7	7.3	7.2	-0.50	0.10	0.00
7	511991.4	479310.4	69	6.7	4.6	4.39	2.31	0.21	0.29
8	512083.4	478981.5	66	10.2	10.3	10.21	-0.01	0.09	0.00
9	512121.3	478786.3	76	8.3	8.4	8.33	-0.03	0.07	0.00
10	512226.2	478547.9	74	7.5	7.3	7.18	0.32	0.12	0.04
11	512471.4	478153.5	53	6.6	7.9	7.77	-1.17	0.13	0.00
12*	512558.9	477901.9	66	7.7	6.9	6.41	1.29	0.49	0.16
12A*	512655.8	477822.4	67	13.9	14	13.3	0.60	0.70	0.08
13**	512697.6	477719	34	4.2	No Data	No Data	No Data	No Data	No Data
13A*	512805.5	477572.1	32	13.42	13.5	13.45	-0.03	0.05	0.00

14	512939.4	477400.9	66	8	7	6.95	1.05	0.05	0.13
15	513157	477192.7	51	5.2	4.6	4.5	0.70	0.10	0.09
16	513299.5	477024.6	30	7.7	7.1	7.07	0.63	0.03	0.08
17	513507.7	476821.1	34	10.7	10.5	10.5	0.20	0.00	0.02
18	513721	476602.3	31	7.2	6.9	6.26	0.94	0.64	0.12
19	513916.6	476354.1	51	6.6	6.5	6.42	0.18	0.08	0.02
20	514174.8	476179.4	32	7	7	6.95	0.05	0.05	0.01
21	514471.5	475965.7	66	7.6	7.6	7.44	0.16	0.16	0.02
22	514656.2	475728.8	101	8.1	8.2	8.12	-0.02	0.08	0.00
23	514889.5	475537.6	60	9.1	9.1	8.49	0.61	0.61	0.08
24*	512603.7	481665.9	14	19.9	19.8	19.72	0.18	0.08	0.02
25*	512607.1	481648.9	184	17.2	17.2	17.31	-0.11	-0.11	0.00
26*	512301.9	481825.5	18	11	10.9	10.87	0.13	0.03	0.02
27*	512475.8	481712.1	20	11.6	11.47	11.41	0.19	0.06	0.02

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.
*baseline for 12A and 24-27 is March 2011.